NOTICE:

"BEST AVAILABLE COPY"

PORTIONS OF THE FOLLOWING DOCUMENT ARE ILLEGIBLE

The Administrative Record Staff

DRAFT FINAL
TECHNICAL MEMORANDUM NO. 8

REVISED PHASE II RFI/RI WORK PLAN (BEDROCK)

Rocky Flats Plant
903 Pad, Mound, and East Trenches

(Operable Unit No. 2)

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant
Golden, Colorado

March 1993

DRAFT FINAL
TECHNICAL MEMORANDUM NO. 8

REVISED PHASE II RFI/RI WORK PLAN (BEDROCK)

Rocky Flats Plant
903 Pad, Mound, and East Trenches

(Operable Unit No. 2)

U.S. DEPARTMENT OF ENERGY

Rocky Flats Plant
Golden, Colorado

March 1993

U NU

REVIEWED FOR CLASSIFICATION/UCNI
BY G. T. Ostdiek
DATE 3-31-93

(4040-110-0027-510) (COVER) (03/11/93 12:16pm)

LIST OF TABLES

LIST OF FIGURES

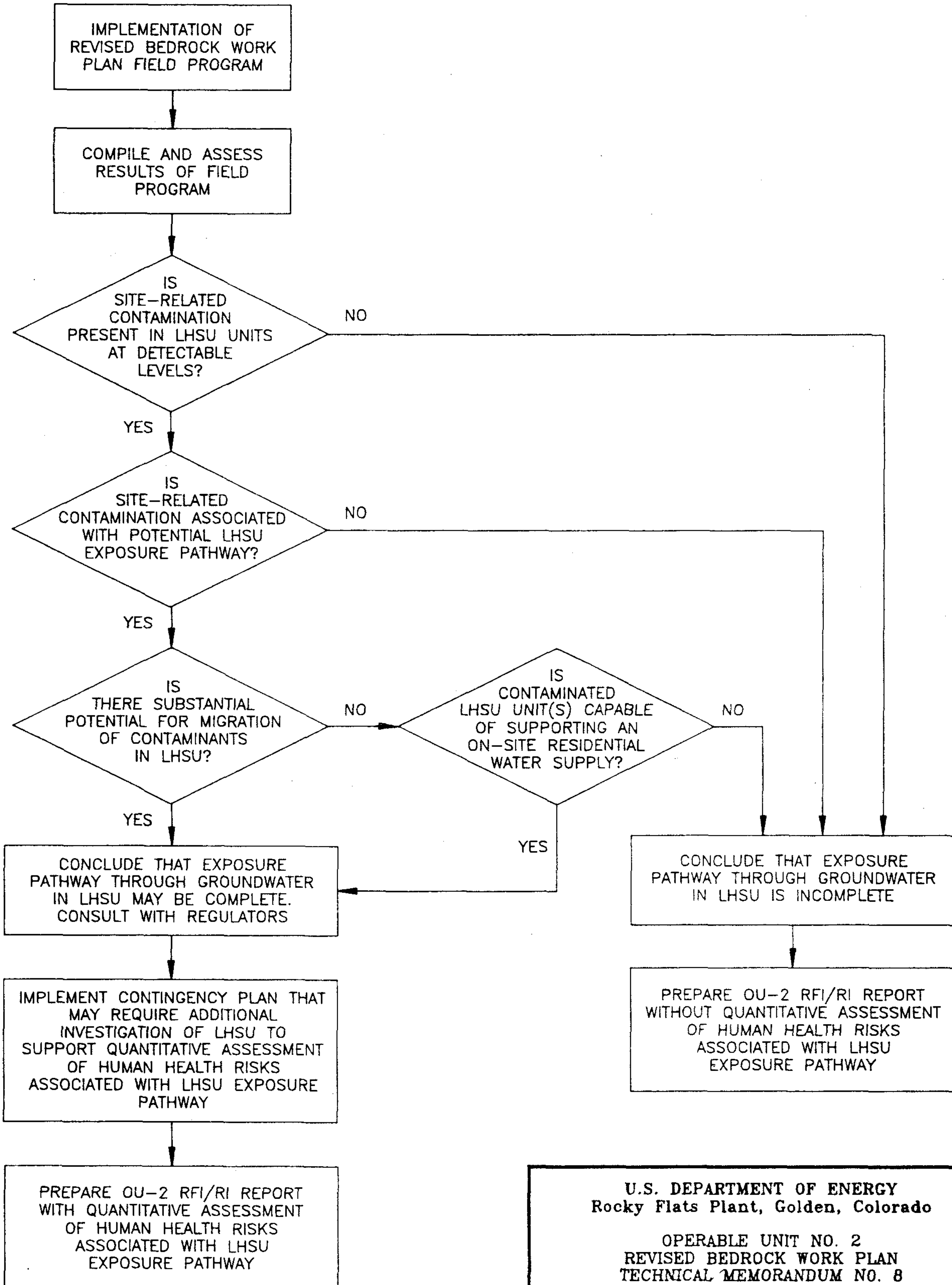
LIST OF PLATES

EXECUTIVE SUMMARY

This technical memorandum presents the Revised Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Work Plan (Bedrock) for the Rocky Flats Plant (RFP) Operable Unit No. 2 (OU-2). This work plan, hereafter referred to as the Revised Bedrock Work Plan, refines and reduces the scope of work for investigation of the Lower Hydrostratigraphic Unit (LHSU) that was presented previously in the Phase II RFI/RI Work Plan (Bedrock) (EG&G 1991e), hereafter referred to as the Bedrock Work Plan. This reduction in scope is appropriate based on a review of data previously collected and currently being compiled as part of the implementation of the Phase II RFI/RI Work Plan (Alluvial) (EG&G 1991b). The existing OU-2 data indicate that substantial LHSU contamination associated with LHSU exposure pathways is not present. Additionally, due to the low permeability and discontinuous nature of the LHSU sandstones, a complete LHSU exposure pathway for health risk to human receptors is unlikely. As such, a quantitative assessment of human health risk for the LHSU will not be performed for the OU-2 RFI/RI Report.

The Revised Bedrock Work Plan focuses on acquiring data to verify that contamination associated with LHSU exposure pathways is limited, and that the LHSU exposure pathway is an incomplete pathway to human receptors. The field investigation program is a focused program designed to incorporate an observational approach that will allow the field results to be evaluated as each field component is completed. With this approach, the investigation of the LHSU can be expedited, while reducing the potential need for additional phases of field investigation. Figure ES-1 illustrates the decision process for using field results, as they are obtained, to evaluate the LHSU as an exposure pathway to human receptors.

The Revised Bedrock Work Plan will be implemented simultaneously with ongoing alluvial site characterization and risk assessment work in order to complete the Phase II RFI/RI Report in the spring of 1994, because of the expected condition that no complete LHSU exposure pathway exists. It is expected that the results of the Revised Bedrock Work Plan will support that assumption. In that case, no quantitative assessment of human health risk associated with the LHSU will be performed for the Draft Phase II/RFI/RI Report. The results of the expedited analysis of the indicator parameters for groundwater will be used to evaluate if the expected condition of an incomplete LHSU pathway is met. Therefore, the actual analytical results from the Revised Bedrock Work Plan will not be used quantitatively in the human health risk assessment. However, the results of the expedited indicator parameter analysis, as well as



* ADDITIONAL INVESTIGATION OF THE LHSU BEYOND THAT DESCRIBED IN THE SAP (SECTION 2) IS NOT INCLUDED IN THE SCOPE OF REVISED BEDROCK WORK PLAN

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DECISION PROCESS
BEDROCK WORK PLAN

FIGURE ES-1

MARCH 1993

3407E17A

available non-validated analytical results for LHSU analytical parameters will be included in the data section of the Draft Phase II RFI/RI Report.

If the expected condition is found not to exist and the LHSU exposure pathway is determined to be complete, the quantitative human health risk assessment will need to be re-evaluated. This may result in delays in the currently identified schedule for submittal of the Draft and Final Phase II RFI/RI Reports. To minimize delays, a contingency plan will be developed so that, if the results of the Revised Bedrock Work Plan do not confirm the assumed site conditions, this plan will be implemented while the field crews are mobilized. The contingency plan will have to be reviewed and approved by EPA/CDH.

The Data Quality Objectives (DQO) process was utilized in developing this technical memorandum. The DQO process is an iterative process designed to focus on decision making and project objectives to ensure that data acquisition activities are logical and cost effective.

Previous field investigations (Phase I and Phase II) conducted at OU-2 have addressed the geologic characterization of the alluvial and bedrock deposits, associated groundwater flow systems, and sources and extent of chemical and radiological contamination. Data for the Upper Hydrostratigraphic Unit (UHSU) and LHSU at RFP were reviewed and utilized in developing this technical memorandum. Substantially more data are available for the UHSU than LHSU because most of the subsurface data collection activities conducted to date have focused on characterizing the UHSU. However, data from 30 existing LHSU wells and 11 borings are available. Based on a review of those data, it appears that potential sources of contamination to LHSU sandstones are limited to secondary groundwater plume sources within the UHSU.

To evaluate potential UHSU plume sources, alluvial/colluvial and No. 1 Sandstone isoconcentration maps for carbon tetrachloride (CCl_4) were prepared (Figures 1-25 and 1-26) to identify UHSU contamination hotspots. Isoconcentration maps for PCE and TCE indicate similar UHSU hotspots for the contaminants. Six substantial CCl_4 hotspots appear to be present in the UHSU as shown on the isoconcentration maps. These UHSU hotspots are likely areas where contamination might be present in the underlying LHSU if migration has occurred between the UHSU and LHSU, therefore the Revised Bedrock Work Plan field investigations will be focused in these areas.

Two potential scenarios for migration of groundwater contamination from the UHSU to LHSU have been proposed. Scenario 1 (Figure 1-27) involves lateral migration of contaminants from the UHSU alluvium and/or No. 1 Sandstone to discharge points beneath the colluvium along the slope of the Woman Creek drainage. The downslope migration of the contaminated water within the colluvium results in localized recharge of the LHSU sandstones that are subcropping beneath the colluvium. Contamination has been found in existing LHSU wells screened in the vicinity of the subcrops. It is expected that LHSU contamination resulting from this scenario will be limited to the vicinity of the subcrops because the lateral hydraulic gradient within the LHSU sandstones should be toward the drainages, thus the contamination should be discharged relatively quickly back into the colluvium. As such, contamination migration is associated with an UHSU exposure pathway through the colluvium, rather than a LHSU exposure pathway.

Scenario 2 (Figure 1-28) involves vertical migration of contamination from the UHSU to LHSU sandstones where LHSU sandstones are in close vertical proximity to the UHSU. Once in the LHSU sandstones, the contaminants potentially migrate laterally within the sandstones or vertically to deeper LHSU sandstone units. As such, contaminant migration for scenario 2 may be associated with a potential LHSU exposure pathway if the sandstones are hydraulically interconnected and laterally continuous.

Of the two scenarios, scenario 2 is of the most concern with regard to the LHSU because it is potentially associated with a LHSU exposure pathway. Scenario 1 is of less concern with regard to a potential LHSU exposure pathway because it is believed to be associated with an UHSU exposure pathway (i.e., migration of contaminants through the colluvium).

Data from existing OU-2 LHSU wells were evaluated to assess identified contamination in the LHSU. Where applicable, the identified contamination was evaluated relative to the LHSU contamination source scenarios discussed above. Based on the available data, chlorinated hydrocarbons (CHCs) such as CCl_4, tetrachloroethene (PCE), and trichloroethene (TCE) have been detected in 10 out of 26 LHSU monitoring wells for which data are available since 1990 (Figure 1-29). Of those 10 wells, seven are located on the north slope of the Woman Creek drainage and are screened in LHSU sandstones near where they subcrop beneath the colluvium. These wells, which have the most consistent and highest concentration detections observed in the LHSU groundwater, are believed to be representative of the scenario 1 mechanism believed to be associated with an UHSU exposure pathway.

The other three LHSU wells with CHC detections are located in the central portion of the OU-2 plateau and may be representative of scenario 2. Such contaminant migration, if it occurs, may be associated with a potential LHSU exposure pathway. However, the evidence for this is limited. In general, these wells have had concentrations of CHCs in the low parts per billion range, usually near the analytical method detection limits. In many cases, the detected CHCs in these wells have also been detected in laboratory blanks indicating possible laboratory-related contamination of the samples. Based on the available data, it appears unlikely that the contamination identified in these wells is indicative of a LHSU exposure pathway.

This technical memorandum discusses the Conceptual Site Model for OU-2 with respect to the LHSU. Potentially exposed human receptors for LHSU groundwater include a future on-site ecological researcher and hypothetical off-site resident (from exposure to contaminated surface water/suspended sediment if contaminated LHSU groundwater were to discharge at a seep), and a hypothetical on-site resident from exposure to contaminated surface water/suspended sediment, or groundwater from a well.

Potential exposure pathways associated with the LHSU have been designated as incomplete for OU-2. This designation is based on existing data that indicate that LHSU contamination is limited where associated with potential LHSU exposure pathways (i.e., scenario 2 type). In addition, the low permeability and discontinuous nature of the LHSU sandstones suggests that there is no viable LHSU migration pathway for the contaminants to reach ground surface, nor is there sufficient well production capability in the LHSU sandstones to support a water supply for on-site residents. Based on this designation, no quantitative assessment of human health risk through LHSU exposure pathways is anticipated for the OU-2 RFI/RI. Contamination believed to be associated with an UHSU exposure pathway (scenario 1) will be quantitatively evaluated in the OU-2 RFI/RI with regard to the associated human health risk.

The objective of the Revised Bedrock Work Plan is to gather data necessary to sufficiently verify the assumption that the LHSU exposure pathway is incomplete. The Revised Bedrock Work Plan field program will investigate the most likely areas for LHSU contamination and will evaluate the permeability of LHSU units in those areas. The field program focuses on gathering data to sufficiently verify the assumption that substantial LHSU contamination associated with a potential LHSU exposure pathway does not exist, or that, if present, the contamination does not pose a risk to human health because the exposure pathway in the LHSU is incomplete.

The Revised Bedrock Work Plan field investigation activities include drilling and sampling of two bedrock boreholes, drilling and sampling of six bedrock pilot boreholes, and installation of 6 to 12 monitoring wells at six locations (Figure 2-1), collecting and analyzing groundwater samples from each newly-installed LHSU monitoring well, and slug testing of each newly-installed LHSU monitoring well. Three of the six locations for monitoring well installation (WC-1, WC-5, and WC-6) were selected to evaluate the potential for vertical migration of

UHSU contamination to LHSU sandstone units (scenario 2). The other three monitoring well locations (WC-2, WC-3, and WC-4) were selected to verify that contaminants detected in LHSU wells along the slope of Woman Creek (scenario 1) are related to localized infiltration of contaminated colluvial water into the subcropping LHSU sandstones. The two borehole locations (SB-1 and SB-2) were selected to investigate the vertical extent of contamination identified previously in LHSU claystones samples.

At locations WC-1, WC-5, and WC-6 the investigation will focus in areas where UHSU contamination has been detected at the highest levels, or where contaminants have been detected previously in the LHSU. The locations, WC-1 and WC-6, were selected because they are within UHSU contamination hotspots (Figure 1-26), and LHSU sandstones are in close vertical proximity to the UHSU. The location, WC-5, was selected because low levels of contamination have been identified in an existing well completed in a LHSU claystone.

To assess whether LHSU contamination is present at locations WC-1, WC-5, and WC-6, a monitoring well will be installed into the uppermost LHSU sandstone unit, or into the LHSU target interval where contamination was detected previously. The results of expedited laboratory analysis of groundwater samples from these wells for a selected indicator parameter suite will indicate the presence or absence of contamination. If contamination is detected, a second monitoring well will be installed to the next deeper sandstone to evaluate the vertical extent of the LHSU contamination. In addition, slug tests will be performed in each new LHSU monitoring well to evaluate the permeability of the LHSU sandstones for use in estimating the potential for contaminant migration within the LHSU.

WC-2, WC-3, and WC-4 will be installed to evaluate the source of contaminants in LHSU sandstones near where they subcrop beneath colluvium along the Woman Creek drainage (i.e., scenario 1). The new wells will be installed upgradient and away from the LHSU subcrop areas so as to be outside the influence of localized recharge from UHSU colluvial water to the LHSU sandstones, if it is occurring. The location for WC-2 was selected to investigate the source of LHSU contamination identified in the Well 1187. The locations for WC-3 and WC-4 were similarly selected to investigate the sources of LHSU contamination identified in Wells 00391 and 1487, respectively. At locations WC-2, WC-3, and WC-4, groundwater samples will be collected and analyzed on an expedited basis for a selected indicator parameter suite to assess whether or not contamination is present. If contamination is not detected, it will be concluded that the contaminants detected in the existing well near the subcrop were introduced to the LHSU sandstone through an UHSU exposure pathway (scenario 1). If contaminants are detected, it will be an indication that the contamination migrated vertically to the LHSU sandstone from an UHSU secondary source area and then migrated laterally within the LHSU sandstone to the existing well near the subcrop location. Such a condition would be associated with a LHSU exposure pathway. In that case, a second well will be installed into the next deeper LHSU sandstone to evaluate the vertical extent of the contamination in the LHSU. In addition, slug tests will be performed in each new LHSU monitoring well to evaluate the permeability of the LHSU sandstones for use in estimating the potential for contaminant migration within the LHSU.

Boreholes, SB-1 and SB-2 (Figure 2-1), will be drilled adjacent to existing Boreholes 09991 and BH2587, respectively, to evaluate the vertical extent of CHC contamination identified in LHSU claystone bedrock samples previously collected in those areas (Figure 1-30 and 1-31). The new boreholes will be drilled to allow collection of samples from intervals below the depth of the samples collected previously (Figure 2-7).

Two sets of groundwater samples will be collected from the newly-installed LHSU monitoring wells and analyzed to evaluate groundwater quality in the LHSU. One set will be submitted to an analytical laboratory for analysis on a quick turn-around basis for a suite of indicator parameters (Table 2-6) selected for their utility and reliability as indicators of site-related contamination. The second set of samples will be submitted to another analytical laboratory for analysis for a more extensive suite of LHSU analytical parameters (Table 2-8).

The sole purpose of the indicator parameter analyses will be to assess whether or not contamination is present in a LHSU unit at a particular location. Specific factors considered in selecting the indicator parameters include: (1) they should have been detected in on-site waste or as existing groundwater contamination at substantial concentrations; (2) they should be mobile and relatively stable and persistent over the flow path of interest; (3) they should be measurable at low concentrations and should be unambiguous with respect to site-related contamination versus sampling/laboratory artifacts; and (4) they should be readily discernable at low levels from naturally occurring conditions.

The purpose of analyzing a second set of samples for a more extensive suite of LHSU analytical parameters is to verify the results of the indicator parameter analyses, and to fully characterize the types of contaminants, if present, in the LHSU at a particular location. The LHSU parameter analysis suite is a refinement of the full analytical parameter list used for the Alluvial Work Plan. Certain parameters or types of parameters were eliminated for the Revised Bedrock Work Plan LHSU parameter analysis suite because they had not been detected to date in UHSU samples at a frequency greater than five percent, are not believed to be present in on-site waste, are believed to be sampling/laboratory artifacts, or are not present at levels above background.

Bedrock claystone samples collected from Boreholes SB-1 and SB-2 will be analyzed for the parameters listed in Table 2-4. This list is similar to the LHSU parameter analytical suite for groundwater, and is tailored for claystone sample analysis.

It is anticipated that most, if not all, of the analytical results for the indicator parameters and some non-validated results for the LHSU analytical parameters will be included in the contamination assessment portion of the Draft Phase II RFI/RI Report to the EPA and CDH. All validated analytical results for the LHSU analytical parameters, including Quality Assurance/Quality Control results, are anticipated to be available for inclusion in the Final Phase II RFI/RI Report.

As previously noted, the quantitative assessment of human health risk associated with the UHSU will be conducted concurrently with the Revised Bedrock Work Plan field investigation. It is assumed that the results of the Revised Bedrock Work Plan field investigation will confirm the assumption that the LHSU exposure pathway to human receptors is incomplete. Therefore, under the proposed schedule, no quantitative assessment of human health risk associated with the LHSU will be performed for the Draft Phase II RFI/RI Report.

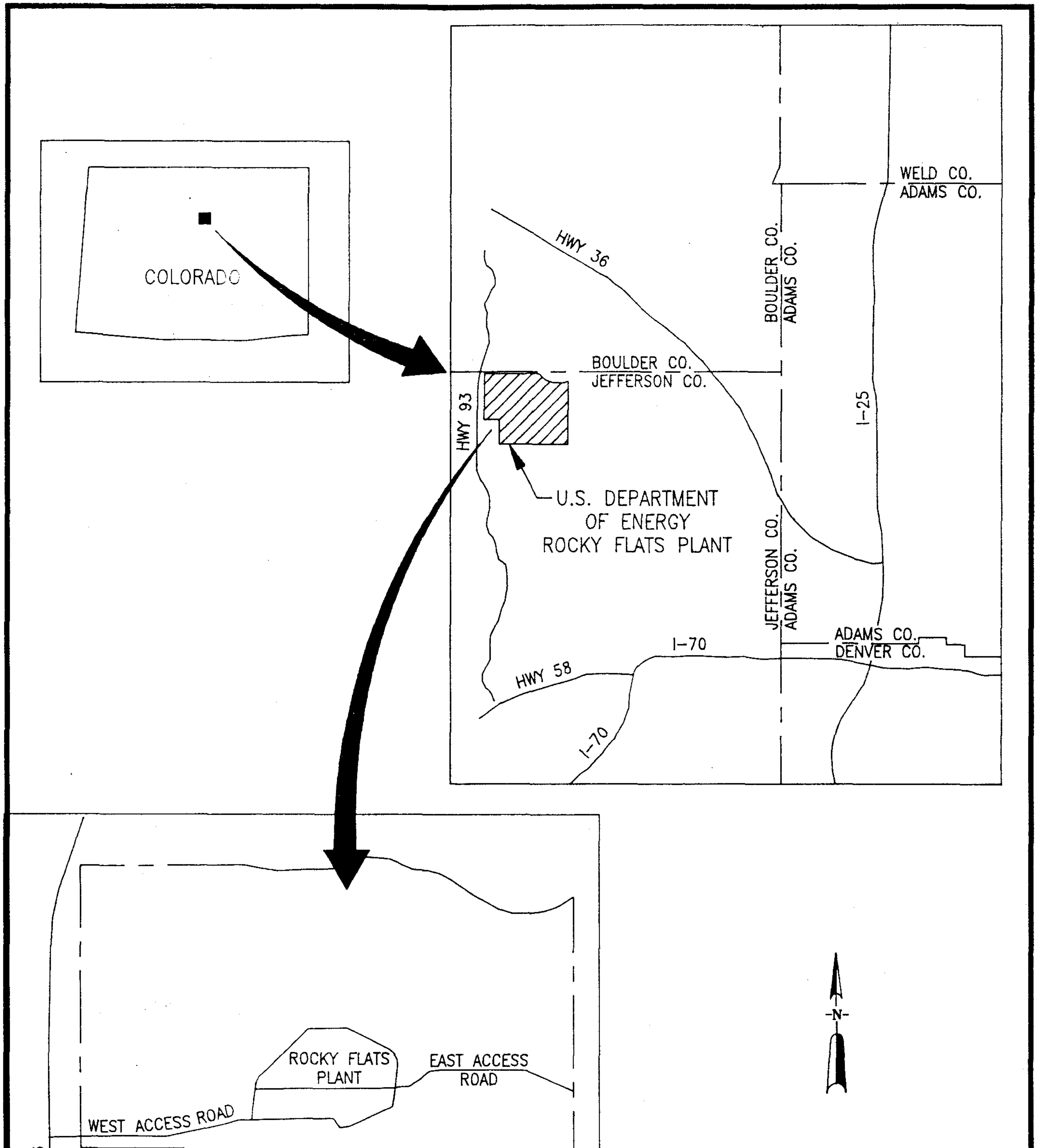
1.0
INTRODUCTION AND APPROACH

1.1 INTRODUCTION

This technical memorandum presents the Revised Bedrock Work Plan for investigation of the LHSU at the Rocky Flats Plant Operable Unit No. 2. The location of RFP and the boundaries of OU-2 are shown on Figures 1-1 and 1-2, respectively.

In developing this work plan, a range of approaches was considered; from the one extreme of assuming that no contamination or exposure pathway potential exists for the LHSU (and, thus, no additional investigation of the LHSU is necessary), to the other extreme of assuming that contamination of the LHSU is extensive and widespread, and that a complete exposure pathway through the LHSU to human receptors is likely (and, thus, a detailed investigation of the LHSU is necessary). To develop the proper approach, available data for OU-2 collected during previous investigations or currently being compiled as part of implementation of the Alluvial Work Plan were reviewed. Those data indicate that, although some contamination is present in LHSU sandstone units at certain locations, substantial LHSU contamination related to potential LHSU exposure pathways does not appear to be present. Additionally, a complete exposure pathway through the LHSU to human receptors appears unlikely due to the low permeability and discontinuous nature of the LHSU sandstone units. Based on these data, the approach assuming no potential for contamination in the LHSU was considered invalid because some LHSU contamination has been identified. Alternatively, the approach assuming wide-spread contamination of the LHSU, and a complete LHSU exposure pathway was also not considered valid based on available data. Instead, the approach for the Revised Bedrock Work Plan was designed to fall between these extremes.

The Revised Bedrock Work Plan refines and reduces the scope of work for investigation of the LHSU that was presented previously in the Bedrock Work Plan. The Bedrock Work Plan, prepared in late 1990 without the benefit of much of the OU-2 data currently available, presented an approach skewed towards characterizing the nature and extent of LHSU contamination under the assumption that widespread LHSU contamination is likely, and the potential for a complete exposure pathway through the LHSU is high (Figure 1-3). As noted above, a review of the more complete set of data currently available for the site does not support this assumption.



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

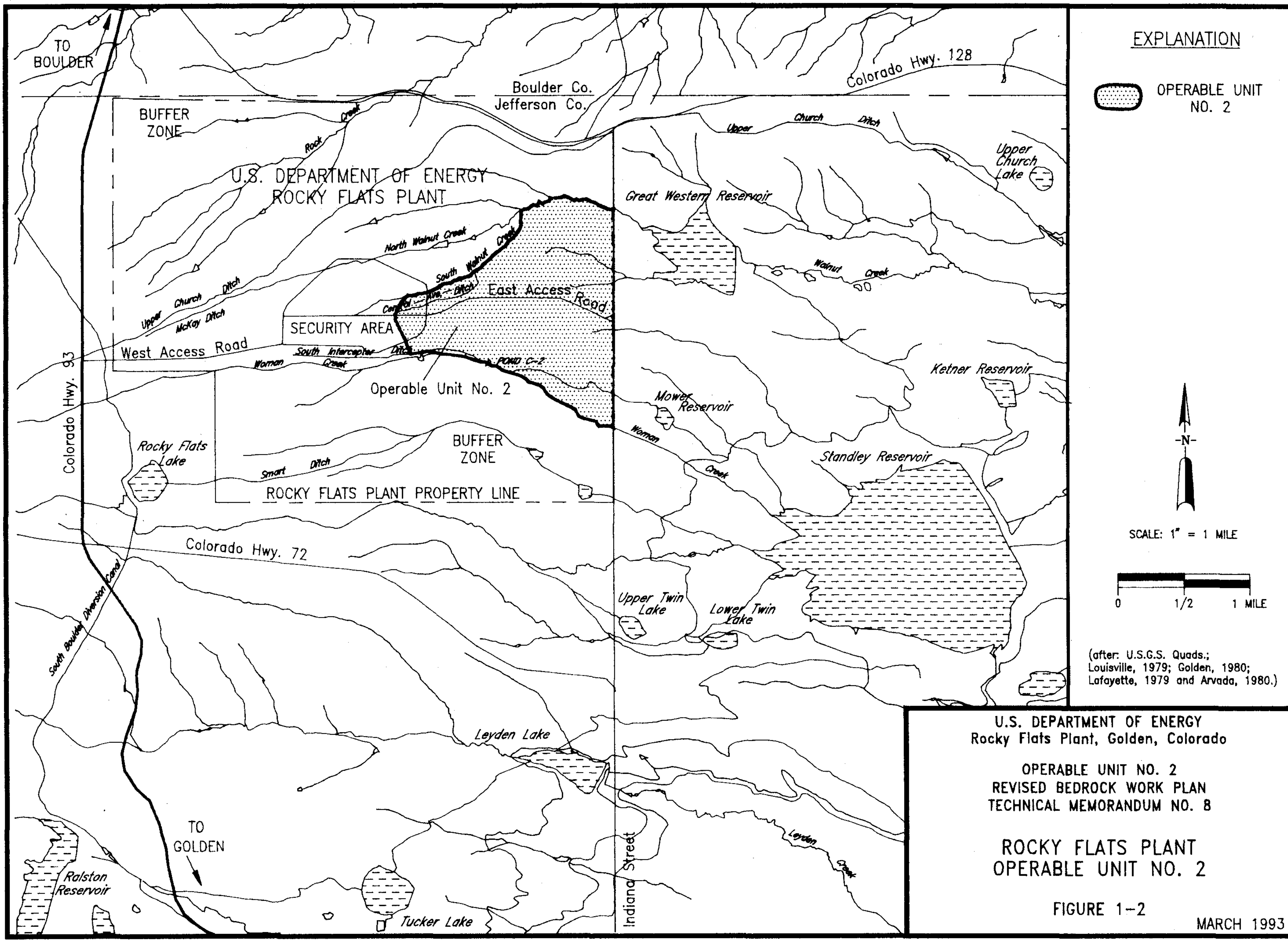
OPERABLE UNIT NO. 2
REVISED LHSU BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

LOCATION OF THE ROCKY FLATS PLANT

FIGURE 1-1

MARCH 1993

R33059.PJ-022091



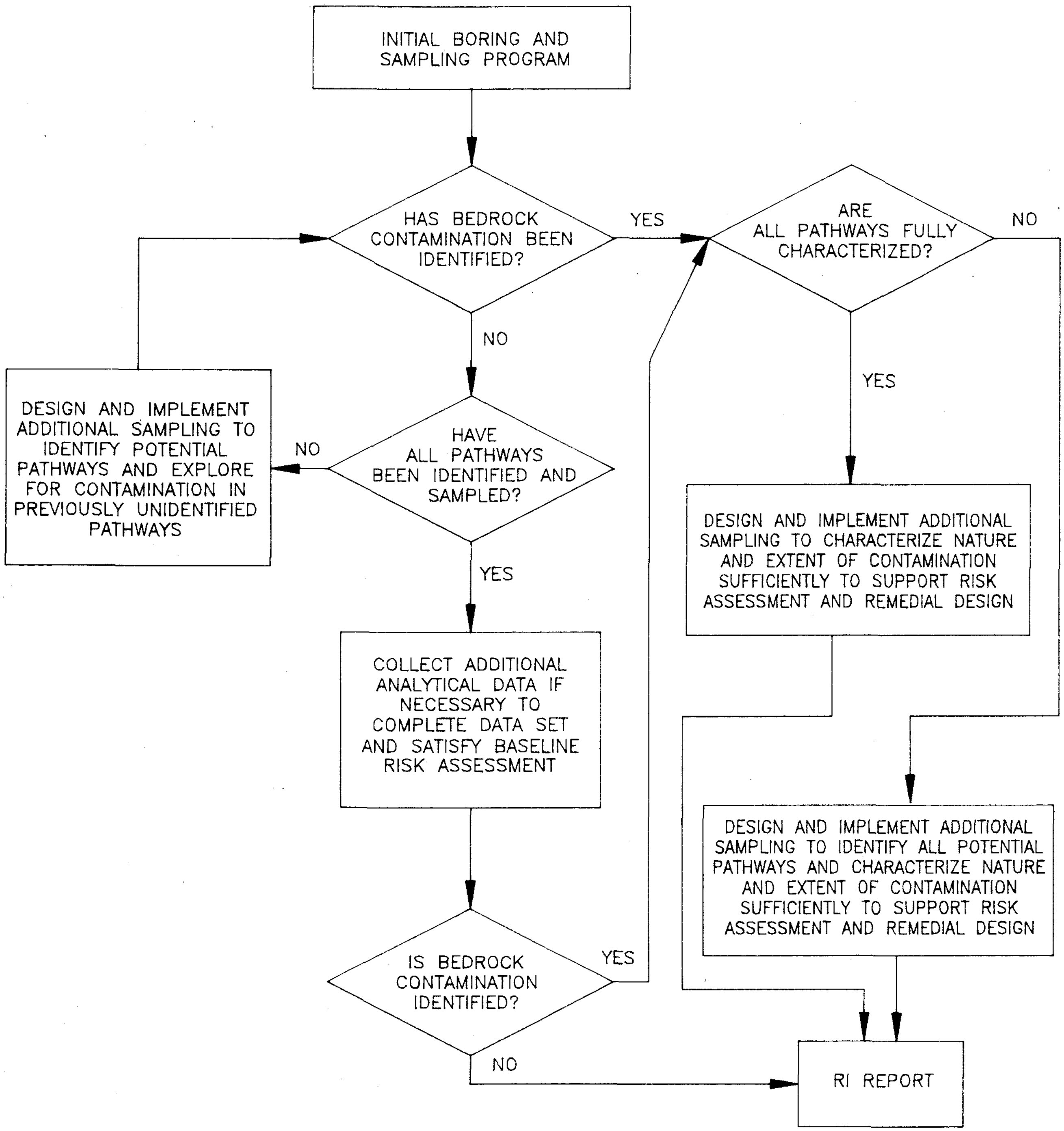
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

ROCKY FLATS PLANT
OPERABLE UNIT NO. 2

FIGURE 1-2

MARCH 1993



NOTE: THIS DIAGRAM IS FIGURE 8-2 OF BEDROCK WORK PLAN (EG&G 1991e)

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

APPROACH FOR PREVIOUS BEDROCK WORK PLAN

FIGURE 1-3

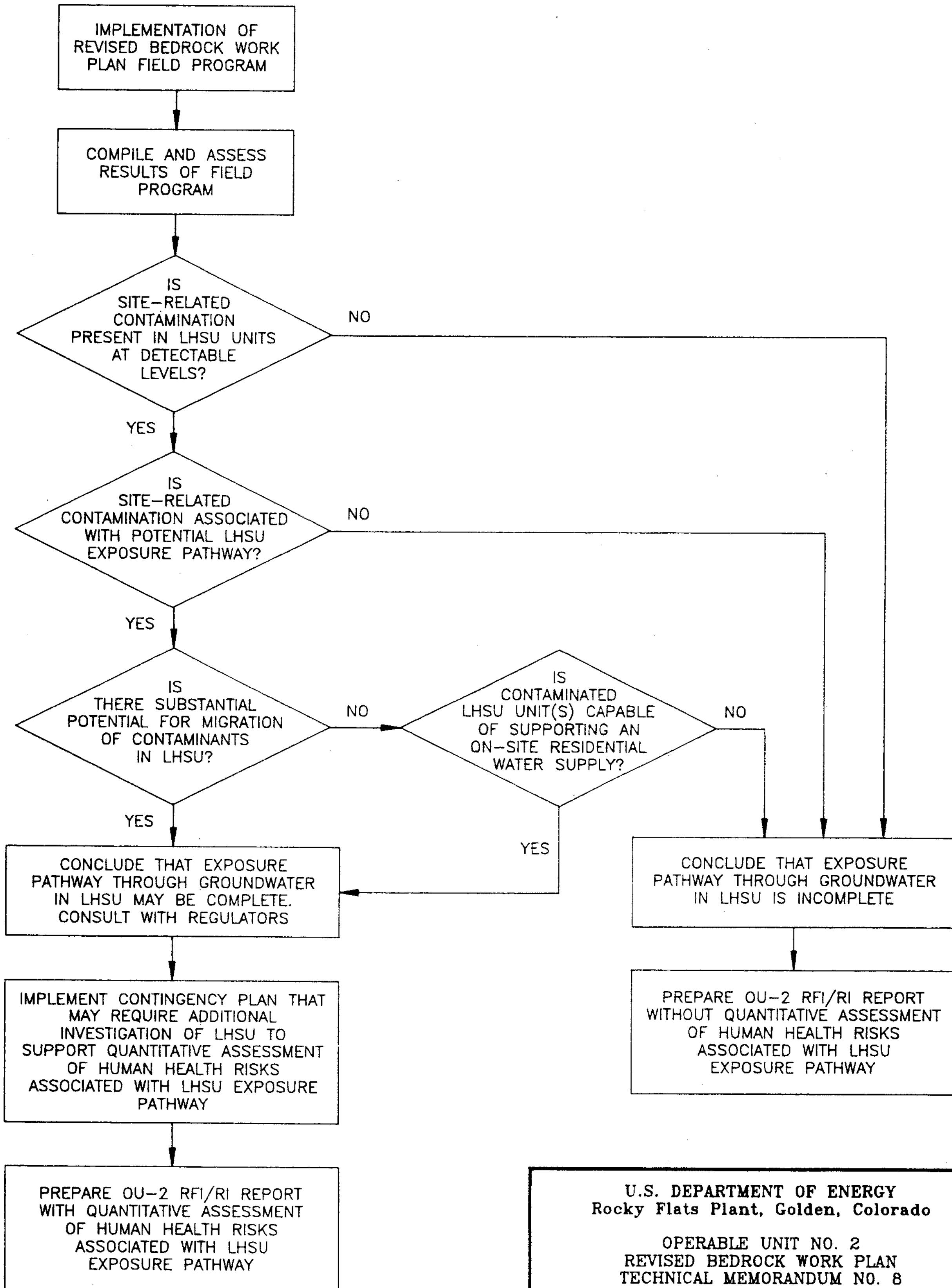
MARCH 1993

3047E16

The Revised Bedrock Work Plan focuses on acquiring data to confirm whether or not substantial contamination associated with potential LHSU exposure pathways exists, and evaluating whether a complete LHSU exposure pathway to human receptors is likely (Figure 1-4). If the results of the Revised Bedrock Work Plan confirm that a complete LHSU exposure pathway is not likely, as indicated by available data, a detailed investigation of the LHSU, as previously proposed in the Bedrock Work Plan, will not be necessary to support an OU-2 RFI/RI Report conclusion that human health risk associated with LHSU exposure pathways is negligible. Alternatively, if the results of the Revised Bedrock Work Plan fail to confirm that a complete LHSU exposure pathway is not likely, then additional investigation may be necessary to support a quantitative assessment of human health risk through a LHSU exposure pathway. A contingency plan will be developed for review and approval by EPA and CDH to minimize delays.

The Revised Bedrock Work Plan field investigation program is a focused program designed to incorporate an observational approach that will allow field results to be evaluated as each field component is completed. With this approach, the investigation of the LHSU can be expedited, while reducing the potential for needing additional phases of field investigation. The Revised Bedrock Work Plan will be implemented simultaneously with ongoing alluvial site characterization and risk assessment work in order to complete the Phase II RFI/RI Report in the Spring of 1994, because of the expected condition that no complete LHSU exposure pathway exists. It is expected that the results of the Revised Bedrock Work Plan will support that assumption. Because of the expected condition, no quantitative assessment of human health risk associated with the LHSU will be performed for the Draft Phase II RFI/RI Report. The results of the expedited analysis of indicator parameters for groundwater will be used to evaluate if the expected condition of an incomplete LHSU pathway is met. Therefore, the actual results from the Revised Bedrock Work Plan will not be used quantitatively in the human health risk assessment. However, the results of the expedited indicator parameter analyses, as well as available non-validated analytical results for the LHSU analytical parameters, will be included in the data section of the Draft Phase II RFI/RI Report.

If the expected condition is found not to exist and the LHSU exposure pathway is determined to be complete, the quantitative human health risk assessment will need to be re-evaluated. This may result in delays in the currently identified schedule for submittal of the Draft and Final Phase II RFI/RI Reports. To minimize delays, a contingency plan will be developed so that, if the results of the Revised Bedrock Work Plan do not confirm the assumed site conditions, the plan will be implemented while the field crews are mobilized. The contingency plan will have to be reviewed and approved by EPA/CDH.



* ADDITIONAL INVESTIGATION OF THE LHSU BEYOND THAT DESCRIBED IN THE SAP (SECTION 2) IS NOT INCLUDED IN THE SCOPE OF REVISED BEDROCK WORK PLAN

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

APPROACH FOR REVISED BEDROCK WORK PLAN

FIGURE 1-4

MARCH 1993

3407E17

The accelerated approach described herein is proposed because it is believed that the potential for human health risk is greatest for the UHSU. This approach will allow completion of the RFI/RI Report in a timely manner so as to address that potential as expediently as possible. In the event that the results of the Revised Bedrock Work Plan do not confirm the assumed site conditions, additional field investigations of the LHSU may be needed to support the Phase II RFI/RI for OU-2.

1.2 DQO PROCESS

The Data Quality Objectives (DQO) process, as outlined in Data Quality Objectives Remedial Activities (EPA 1987), was utilized in developing this technical memorandum. The DQO process ensures that the project objectives are well defined, identifies the environmental data necessary to meet those objectives, and ensures that the data collected are sufficient and of adequate quality for the intended use.

The DQO process is an iterative process designed to focus on decision making and project objectives to ensure that data acquisition activities are logical and cost effective. The DQO process incorporates three stages. Although the three stages are discussed sequentially in this document, they are implemented in an interactive and iterative manner, whereby all DQO elements are continually reviewed and re-evaluated. As such, the DQO process is integrated with development and implementation of the Sampling and Analysis Plan (SAP) and may be revised as needed, based on the results of each data collection activity. DQOs are developed using the three-stage process described in the following sections as tailored to the Revised Bedrock Work Plan field investigation program.

<u>Stage 1</u> (Identify Decision Types) defines the types of decisions that will be made regarding site remediation. These decisions are based on input from the identified data users (Section 1.2.1.1) (e.g., risk assessment scientists and remedial design engineers). In Stage 1, available site information is compiled and analyzed (Section 1.2.1.2) in order to develop a Conceptual Site Model (Section 1.2.1.3). The information obtained in Stage 1 is used to identify decisions to be made and deficiencies (data gaps) in the existing information. The outcome of Stage 1 is a definition of the objectives of the site investigation (Section 1.2.1.4).

<u>Stage 2</u> (Identify Data Uses/Needs) involves specifying the data necessary to meet the objectives and fill data gaps defined in Stage 1. Stage 2 includes selecting the sampling

approaches and the analytical options for the site, including evaluating multiple-option approaches to allow more timely or cost-effective data collection and evaluation.

In Stage 3 (Design Data Collection Program), the methods to be used to obtain data of acceptable quality are specified in products such as the SAP or the Work Plan.

1.2.1 Stage 1 - Decision Types

1.2.1.1 Data Users

Physical and chemical data collected during implementation of the Revised Bedrock Work Plan field investigation program will be incorporated into the OU-2 RFI/RI Report, and will provide additional supporting data for the OU-2 Human Health Risk Assessment and feasibility study. The primary data users will be geologists, hydrogeologists, chemists, risk assessment scientists, statisticians, and feasibility study engineers. If additional detailed information is necessary for remedial design/remedial action, it will be collected as needed.

1.2.1.2 Results of Previous Investigations

Previous field investigations (Phase I and Phase II) conducted at OU-2 have addressed the geologic characterization of the alluvial and bedrock deposits, associated groundwater flow systems, and sources and extent of chemical and radiological contamination. Locations of boreholes and monitoring wells from previously conducted field investigations and other site features and landmarks are shown on Figures 1-5 and 1-6 (for enlargements, see Plates 1-1 and 1-2). The results of the previous investigations are available for review in previous reports (EG&G 1991b,e; 1992b) and will be presented in the OU-2 Phase II RFI/RI Report to be completed in early 1994. Interpreted data and results from previous investigations pertinent to the assessment of the nature and extent of contamination within the LHSU are included in this document. The primary references for data used in this Revised Bedrock Work Plan include: the Final OU-2 Phase II RFI/RI Work Plans (Alluvial and Bedrock, EG&G 1991b,e); Final Phase II Geologic Characterization Data Acquisition Report (EG&G 1992b); and Final Task 3 Shallow, High-Resolution Seismic Reflection Profiling in OU-2 (EG&G 1991f).

Geologic Units Within the OU-2 Area

The near-surface geologic units within OU-2 consist of surficial unconsolidated deposits (Quaternary), underlain by bedrock units (Upper Cretaceous). The Quaternary deposits within

OU-2 consist of Rocky Flats Alluvium, terrace alluvium, valley-fill alluvium, and colluvium. Near-surface bedrock units are comprised of sandstones, siltstones and claystones of the Upper Cretaceous Arapahoe and Laramie Formations. Figure 1-7 shows a generalized stratigraphic column for the OU-2 area.

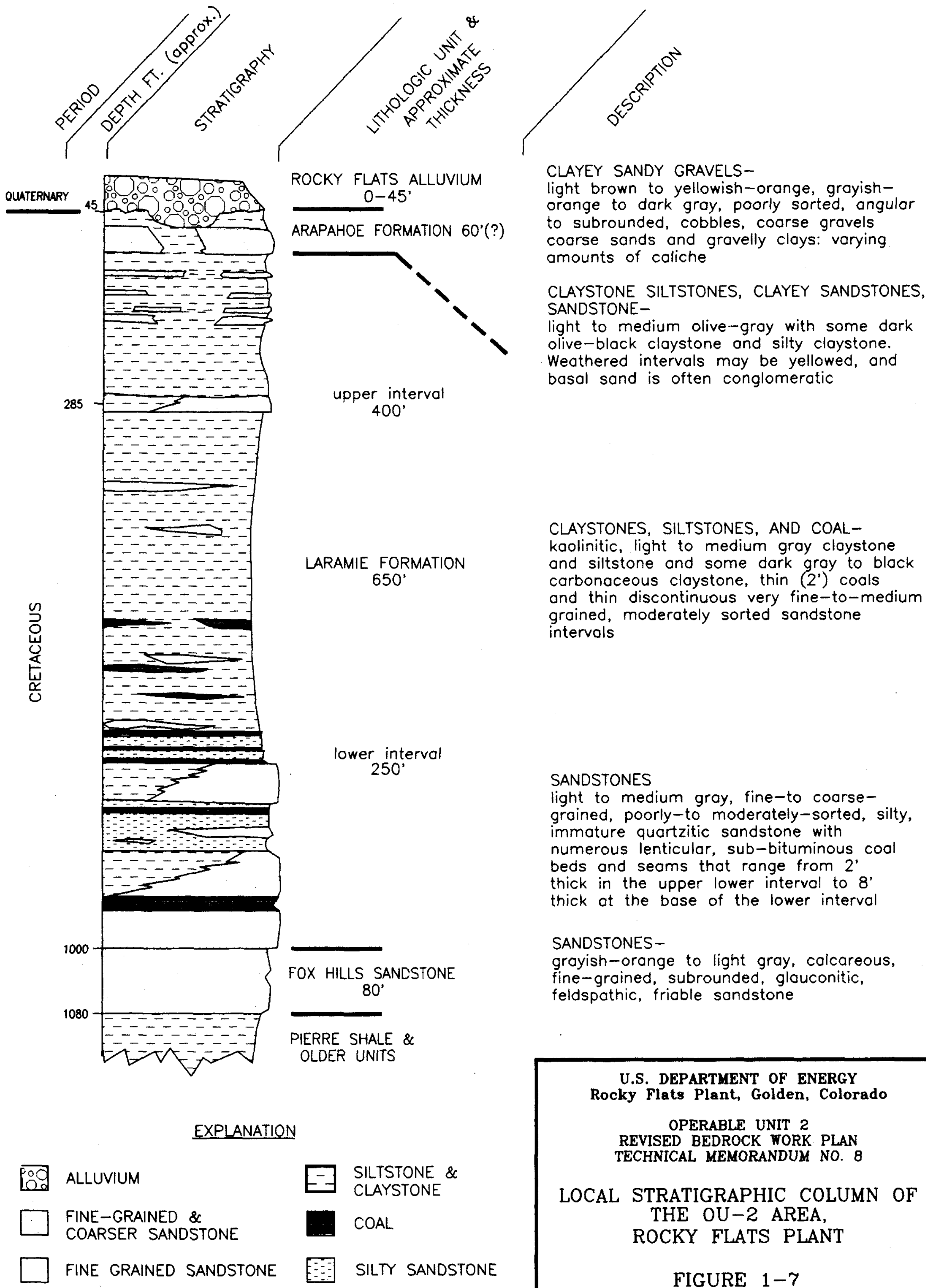
Two hydrostratigraphic units, the UHSU and LHSU, have been identified at OU-2 (Figure 1-8). The UHSU includes the colluvium, valley fill alluvium, Rocky Flats Alluvium, and the subcropping sandstone of the Arapahoe Formation, known locally as the No. 1 Sandstone. This sandstone is hydraulically connected with the overlying alluvium, and therefore is considered part of the UHSU. The LHSU includes the underlying bedrock units of the Laramie Formation which are not hydraulically connected to the overlying alluvium. The boundary between the UHSU and the LHSU is defined at the base of the unconsolidated deposits or the base of the No. 1 Sandstone, where present.

UHSU Geology and Hydrogeology

Colluvial materials in OU-2 were derived from slope wash, slumping, and creep of the Rocky Flats Alluvium, terrace alluvium, and the Arapahoe and Laramie Formations. The colluvium consists of clays, sands, and gravels ranging in thickness from a few feet to 20 feet. Colluvium derived from the Rocky Flats Alluvium characteristically covers the alluvial/bedrock contact along the hillsides. Valley-fill alluvium in the active stream channels of South Walnut and Woman Creeks consists of reworked older alluvial, colluvial, and bedrock units. Remnants of older valley fill alluvium are located as distinct terraces along the walls of South Walnut and Woman Creeks. These terraces are composed mainly of reworked Rocky Flats Alluvium and are only a few feet in thickness.

The Rocky Flats Alluvium is an alluvial fan deposit that overlies an extensive erosional bedrock surface. The deposit beneath OU-2 is composed of a topsoil layer underlain by up to 45 feet of poorly to moderately sorted, cobble gravel. The matrix characteristically consists of coarse sand but may include clay as well. The deposit also contains lenses of clay, silt and sand and varying amounts of caliche, usually found in the upper half of the deposit. Boulders are occasionally encountered in the gravel.

The Arapahoe Formation is the uppermost bedrock formation, which unconformably underlies the unconsolidated deposits at OU-2. The Arapahoe Formation consists of sandstones, claystones, siltstones, and occasional lignitic coal seams and ironstones deposited in a fluvial system as channel, point bar, and overbank deposits. This formation ranges in thickness from



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

LOCAL STRATIGRAPHIC COLUMN OF THE OU–2 AREA, ROCKY FLATS PLANT

FIGURE 1–7

MARCH 1993

R33151

0 feet to approximately 60 feet in the vicinity of OU-2 and has an approximate dip of less than 2 degrees to the east. The channel-shaped fluvial sequences incised into the claystones are composed of predominately fine-grained sands and silts.

The Rocky Flats Alluvium, and other unconsolidated surficial deposits, were deposited on an erosional surface incised into the underlying bedrock units of the Arapahoe and Laramie Formations. This erosional bedrock surface beneath OU-2 is shown in Figure 1-9. Major features include: 1) a large, northeast trending paleochannel, or scour, which is present to the southwest of the 903 Pad and extends northeastward to the Northeast Trenches Area, 2) a north-south trending bedrock step that is located directly beneath the Southeast Trenches Area, and 3) two northeast trending paleoridges that flank the paleochannel. The north paleoridge is present beneath the Mound Area and extends northeastward to the Northeast Trenches Area. The south paleoridge is present south of the 903 Pad Area and extends northeastward to the Southeast Trenches Area.

Erosion of the bedrock surface and subsequent burial by Rocky Flats Alluvium has positioned the alluvium in direct contact with bedrock sandstones, siltstones, and claystones. The uppermost sandstone bedrock unit, referred to locally as the No. 1 Sandstone, is believed to be part of the Arapahoe Formation (EG&G 1992b).

The No. 1 Sandstone is interpreted to be a fluvial sand channel deposit ranging in thickness from 0 to 48 feet. This heterogeneous sandstone body is interbedded with siltstone and claystone layers. Figure 1-10 is a map of the areal extent of the No. 1 Sandstone and the contact zones between the No. 1 Sandstone and the overlying alluvium and colluvium. Substantial areas of the No. 1 Sandstone are known to subcrop beneath the Rocky Flats Alluvium in the OU-2 area. This map shows the estimated areal extent and boundaries of the No. 1 Sandstone channels in OU-2 and the areas where the Quaternary paleochannels have eroded the claystone which originally covered the No. 1 Sandstone. The northern edge of the No. 1 Sandstone has been eroded along the valley of the South Walnut Creek drainage, resulting in subcropping sandstone beneath the colluvium along the southern slope of this drainage. The presence of subcropping sandstone, although not directly visible in most cases due to overlying colluvium, has been inferred from the presence of numerous seeps along the slope. The southern edge of the No. 1 Sandstone, within OU-2, is depositionally bounded by claystone. This depositional edge can be seen on Figure 1-10, near Central Avenue between the boundaries of the Northeast and Southeast Trench Areas. Because of this depositional boundary, there is limited subcropping of the No. 1 Sandstone along the Woman Creek drainage to the south.

Groundwater in the UHSU exists under unconfined conditions except where portions of the No. 1 Sandstone are bounded vertically by claystone resulting in partially confining conditions within the sandstone. Recharge to the UHSU within OU-2 occurs from infiltration of precipitation, and potentially from groundwater inflow within the UHSU No. 1 Sandstone from the area west of OU-2. In general, groundwater levels reach their highest in the spring and early summer, when precipitation is high and evapotranspiration is low. Groundwater levels decline during the remainder of the year except for periodic fluctuations in response to precipitation events.

Figure 1-11 is a map of the potentiometric surface within the Rocky Flats Alluvium and Colluvium for the first quarter of 1992, which represents the low water level period. The map for the first quarter of 1992 was selected because it includes data for wells installed during implementation of the Alluvial Work Plan and represents the most complete water level data set available. This map shows the primary directions of groundwater flow in the alluvium/colluvium. It is anticipated that groundwater flow directions during high water level periods will be similar.

Groundwater flow in the Rocky Flats Alluvium is generally from the west to the east and locally follows the scoured paleochannels in the top of the underlying bedrock. Alluvial groundwater discharges at seeps and springs on the hillsides of OU-2 at the contact between the alluvium and claystone bedrock. This water is either consumed by evapotranspiration or flows downslope as surface flow or through colluvial deposits to South Walnut or Woman Creeks. At the eastern end of the Northeast Trenches Area, groundwater following an alluvial paleochannel discharges as a contact seep into the South Woman Creek drainage just west of B-5 pond. Alluvial groundwater also flows into the underlying No. 1 Sandstone bedrock where the sandstone is in direct hydraulic communication with the alluvium.

Figure 1-12 is a map of the potentiometric surface within the No. 1 Sandstone for the first quarter of 1992. As with the Alluvium/Colluvium potentiometric surface map, this period represents the most complete water level data set available for the No. 1 Sandstone. It is expected that flow directions in the No. 1 Sandstone during the high water level period will be similar. Figure 1-12 shows that the direction of groundwater flow in the No. 1 Sandstone is generally from west to east, but may be locally controlled by the geometry of the sandstone channel. A northward flow component in the No. 1 Sandstone channel causes groundwater to discharge at seeps upslope from the B-1 and B-2 Ponds in the South Woman Creek drainage.

LHSU Geology and Hydrogeology

The Laramie Formation, which appears to conformably underlie the Arapahoe Formation, is composed of upper and lower units. Both units have an approximate dip of less than 2 degrees to the east. The upper unit, which is of concern at OU-2 because of its shallow depth and potential for communication with the UHSU at its upper boundary, is comprised of approximately 400 feet of deltaic claystones, siltstones, and some silty sandstones with an occasional coal layer. The lower unit, which is approximately 250 feet thick, is composed of several sandstone layers and many coal seams. The lower unit is not of concern with respect to OU-2 because of its depth (i.e., greater than about 450 feet) and the substantial thickness of intervening claystones and siltstones between the UHSU and the lower unit. Therefore, the remaining discussion of the LHSU focuses on the upper unit of the Laramie Formation.

Previous investigations have identified several relatively shallow sandstone intervals within OU-2 bedrock units. Recent geologic work by EG&G (1992b) and ongoing studies, suggest that the uppermost sandstone, known locally as the No. 1 Sandstone, is Arapahoe Formation and the deeper sandstones are Laramie Formation.

The LHSU is composed of upper Laramie Formation deltaic claystones, siltstones, and some fluvial silty sandstones. The claystones and silty claystones are light-to-medium olive-gray, and occasionally olive-black. The sandstones are light gray and olive-gray, very fine-to-medium grained, moderately sorted, subangular to subrounded, silty, clayey, and quartzitic. These fine-grained sediments indicate a low-energy depositional environment. In such an environment, low-energy streams meander across a plain, developing coalescing or switching distributary channels over time. These channel deposits are generally fining-upward sequences of fine-to-medium grained sands and silts, with some clays. During floods, overbank sediments are deposited and channel levees are breached by crevasse splays. These overbank and crevasse splay deposits are predominately very-fine grained sands, silts and clays, with the finer sediments deposited further out on to the floodplain. Abandoned channels are filled with fine-grained sediments such as clays and silts, and some coals. Interdistributary areas are usually enclosed, shallow water environments depositing predominately clays and organics with periodic flood silts. The results of lithological logging of the OU-2 bedrock units support a low-energy depositional environmental (EG&G 1992b).

A location map and a legend page for geologic cross-sections can be found on Figures 1-13 and 1-14. A network of cross-sections (Figures 1-15 through 1-23) aids in evaluating sandstone geometries and estimating the lateral extent of the siltstone and silty sandstone intervals within the upper Laramie claystones. Cross-sections BA-BA' through BD-BD' are north-south strike sections and BV-BV' through BZ-BZ' are west-east dip sections. The LHSU (Laramie Formation) sandstone correlations are based on stratigraphic positioning relative to elevation. Table 1-1 lists the 30 LHSU monitoring wells drilled to date in the OU-2 area and provides associated data on each well.

The No. 1 Sandstone channel has incised into the LHSU at several known locations. At some locations, the No. 1 sandstone is in direct contact with or in close vertical proximity to the uppermost underlying LHSU sandstone (Figures 1-17, 1-18, 1-19, 1-20, and 1-21). As such, there is the potential for hydraulic communication between sandstones of the UHSU and LHSU. The quantity of water transmitted from the UHSU to LHSU is believed to be limited, however, due to the low permeability of the silty LHSU sandstones, as discussed below. Based on the wells drilled to date, the contact between the No. 1 Sandstone and the uppermost LHSU sandstone has been identified in boreholes primarily on color, grain size, competency, lamination, apparent moisture content, and content of carbonaceous material. The No. 1 Sandstone is predominately dusky yellow, has high sand content with possible frosted grains, is friable, and contains a trace of carbonaceous material. The LHSU sandstones are predominately gray to olive-gray, have a lower percentage of sand, a higher percentage of clay, an abundance of laminae, are more competent, and have an increased amount of carbonaceous material. Based on observations during drilling of core collected from LHSU sandstones, the sandstones appeared to have a lower permeability than the UHSU No. 1 Sandstone, as discussed below.

The LHSU sandstones are primarily distributary channel deposits and likely represent the most permeable intervals of unfractured LHSU bedrock. Seven of the eight aquifer tests performed on various LHSU sandstones and siltstones indicate hydraulic conductivities in the range of 10^{-5} to 10^{-6} centimeters per second (cm/s) or less (Table 1-2). The sandstones are approximately 15 feet thick or less, except where channels are stacked or have coalesced, which can result in a thick sandstone sequence interbedded with thinner siltstone and claystone layers. Generally, these sandstones are laterally discontinuous (Figures 1-15 through 1-23). Several are believed to subcrop beneath the colluvium along the north hillsides of the Woman Creek drainage, as shown in sections BA-BA' and BC-BC' (Figures 1-15 and 1-17).

TABLE 1-1
SUMMARY OF EXISTING
OU-2 LHSU MONITORING WELLS

Well Number	Geologic Strat of Completion	State Northing (ft.)	State Easting (ft.)	Ground Surface Elev. (ft.)	Top of Casing Elev. (ft.)	Depth Bedrock (ft.)	Elevation Bedrock (ft.)	Depth to Top of Screen	Depth to Bottom of Screen	Elevation Top of Screen	Elevation Bottom of Screen	Depth to Bottom MW	Elevation Bottom MW
903 Pad Area													
1187	Kl (ss)	748409.10	2086100.16	5913.60	5915.12	5.2	5908.40	15.20	20.25	5898.40	5893.35	20.25	5893.35
1287	Kl (silt)	748580.60	2086066.48	5934.81	5936.30	3.5	5931.31	4.92	10.00	5929.89	5924.81	10.25	5924.56
1487	Kl (ss)	748228.20	2086616.02	5854.98	5856.56	5.2	5849.78	19.00	24.05	5835.98	5830.93	24.30	5830.68
1687	Kl (silt)	749129.89	2086248.98	5969.49	5970.79	22.2	5947.29	100.00	125.00	5869.49	5844.49	125.24	5844.25
3087	Kl (silt)	748089.51	2087424.09	5810.12	5811.77	16.0	5794.12	85.79	94.35	5724.33	5715.77	94.35	5715.77
4587	Kl (ss)	748312.83	2085451.38	5949.32	5950.91	3.0	5946.32	89.50	101.05	5859.82	5848.27	101.30	5848.02
6286	Kl (ss)	748142.95	2085724.77	5902.01	5903.18	22.0	5880.01	25.22	35.19	5876.79	5866.82	35.19	5866.82
00391	Kl (ss)	748886.27	2086805.24	5920.84	5922.40	16.9	5903.94	16.8	21.8	5904.04	5899.04	23.80	5897.04
09691	Kl (ss)	748571.86	2086038.21	5935.64	5937.05	3.1	5932.54	6.0	14.0	5929.64	5921.64	16.00	5919.64
11791	Kl (cs)	748900.08	2086785.87	5923.29	5925.03	6.9	5916.39	•8.7	13.7	5914.59	5909.59	15.70	5907.59
B315289	Kl (ss)	749225.00	2086766.00	5963.20	5965.21	19.0	5944.20	91.00	98.00	5872.20	5865.20	NA	NA
Mound Area													
1887	Kl (ss)	749404.14	2086338.67	5967.99	5969.49	27.0	5940.99	127.00	133.45	5840.99	5834.54	133.70	5834.29
2087	Kl (cs)	749634.35	2086154.92	5968.66	5970.14	11.8	5956.86	107.26	116.11	5861.40	5852.55	116.36	5852.30
2287	Kl (ss)	749923.52	2085821.53	5930.70	5931.18	12.8	5917.90	81.41	88.46	5849.29	5842.24	88.70	5842.00
3486	Kl (ss)	750161.62	2086193.17	5912.00	5913.95	13.5	5898.50	44.24	56.25	5867.76	5855.75	56.25	5855.75
N.E. Trenches Area													
386	Kl(ss)	750543.47	2093777.93	5676.24	5677.86	8.0	5668.24	10.40	23.70	5665.84	5652.54	23.70	5652.54
06491	Kl (ss)	751192.86	2093867.28	5671.45	5673.25	2.2	5669.25	10.9	15.9	5660.55	5655.55	17.40	5654.05
46692	Kl (ss)	749554.30	2087076.60	5956.20	5958.25	NA	NA	72.3	87.3	5883.90	5868.90	90.10	5866.10
46792	Kl (silt)	749538.40	2087080.30	5956.30	5958.44	24.5	5931.80	97.1	112.1	5859.20	5844.20	114.90	5841.40
46892	Kl (ss)	749524.40	2087086.80	5956.70	5958.36	NA	NA	147.4	162.4	5809.30	5794.30	165.20	5791.50
B217289	Kl (ss)	750563.30	2093776.40	5777.60	5779.10	5.1	5772.50	109.80	134.20	5667.80	5643.40	136.40	5641.20
B217489	Kl (ss)	749454.00	2086818.00	5961.20	5963.23	25.0	5936.20	142.03	146.43	5819.17	5814.77	148.66	5812.54
B217589	Kl (cs)	749817.00	2087189.00	5952.90	5954.89	16.7	5936.20	85.23	90.74	5867.67	5862.16	85.98	5866.92
B217689	Kl (ss)	749628.54	2086745.14	5960.53	5961.87	22.0	5938.53	98.52	102.91	5862.01	5857.62	105.13	5855.40
S.E. Trenches Area													
2887	Kl (silt)	749438.46	2088090.16	5947.56	5949.90	45.5	5902.06	187.37	197.37	5760.19	5750.19	197.70	5749.86
3187	Kl (ss)	749499.73	2088308.84	5945.31	5947.46	44.0	5901.31	110.66	129.41	5834.65	5815.90	129.64	5815.67
3487	Kl (silt)	749835.88	2087931.43	5945.60	5947.22	18.0	5927.60	97.29	104.29	5848.31	5841.31	104.49	5841.11
4086	Kl (cs)	749610.53	2088504.64	5943.85	5944.89	45.0	5898.85	88.00	111.50	5855.85	5832.35	111.50	5832.35
B217789	Kl(cs)	749494.00	2087341.00	5954.90	5956.85	23.6	5931.30	52.00	63.84	5902.90	5891.06	92.94	5861.96
B317189	Kl (ss)	748807.00	2093921.00	5725.00	5726.64	8.0	5717.00	60.60	75.10	5664.40	5649.90	81.40	5643.60

Explanation

cs = claystone
silt = siltstone
ss = sandstone
Kl = Laramie Formation

MW = Monitoring Well
NA = Data Not Available

DRAFT

TABLE 1-2

HYDRAULIC CONDUCTIVITY VALUES FOR LHSU BEDROCK UNITS BASED ON AQUIFER TESTS IN THE OU-2 AREA*

Well Number	LHSU Lithology	Slug Test Results (cm/s)	Drawdown Recovery Test Results (cm/s)	Geometric Mean of Packer Test Results for Screened Interval (cm/s)
386	Sandstone	--	8×10^{-5}	--
3486	Sandstone	1×10^{-3}	2×10^{-5}	--
6286	Sandstone	6×10^{-6}	--	--
1487	Sandstone/Siltstone	2×10^{-5}	--	--
1687	Siltstone	2×10^{-6}	--	3×10^{-7}
2087	Claystone	--	--	1×10^{-7}
2287	Sandstone/Siltstone	--	--	2×10^{-6}
3187	Sandstone	2×10^{-6}	--	--
3487	Siltstone	1×10^{-5}	--	--
OB20791	Claystone	-------- No Results Reported --------		

*Rockwell International, 1987b and DOE, 1992c.

Groundwater flow between the UHSU and LHSU, and within the LHSU sandstones, is believed to be limited due to the low permeability of the LHSU units. Groundwater in the LHSU sandstones is believed to occur under confined conditions except where these sandstones subcrop along the drainage slopes. The flow in the LHSU sandstones is believed to be largely controlled by sandstone geometry, and is generally from west to east.

Contamination Identified in the UHSU

Site-related contamination in the UHSU has been investigated extensively. Most recently, the Alluvial Work Plan was implemented to characterize the nature and extent of contamination in the UHSU. The following paragraphs discuss the sources and extent of UHSU contamination as it relates to the Revised Bedrock Work Plan. This is followed by a discussion of the potential sources of contamination to the LHSU, and then by a discussion of contamination that has been identified in the LHSU to date.

OU-2 contains the 903 Pad, Mound, and Northeast and Southeast Trenches Areas. Several individual hazardous substance sites (IHSS's), as shown in Figure 1-24, are included in each area. These IHSS's are the primary sources of contamination to the UHSU within OU-2.

Based on previous investigations, the chlorinated hydrocarbons (CHCs) of carbon tetrachloride (CCl_4), tetrachloroethene (PCE), and trichloroethene (TCE) have been identified as primary organic contaminants of concern in the UHSU. Because CHCs are present in the UHSU at high concentrations and are relatively mobile in the dissolved phase in groundwater, they are considered the most likely contaminants to migrate to the LHSU if there is a migration pathway between the UHSU and LHSU. Therefore, the following discussion focuses on CHCs because of their potential to occur as contaminants in the LHSU.

Alluvial/colluvial and No. 1 Sandstone isoconcentration maps for CCl_4 were constructed to identify CHC hotspots in the UHSU (Figures 1-25 and 1-26). These USHU hotspots identify likely areas where contamination might be present in the underlying LHSU if migration has occurred between the UHSU and LHSU. Isoconcentration maps prepared for PCE and TCE indicate similar UHSU hotspot locations for those contaminants (with some exceptions) and, therefore, are not included in this technical memorandum. Table 1-3 lists UHSU CHC concentrations for selected wells. Table 1-4 lists LHSU CHC concentrations for the 30 LHSU wells.

TABLE 1-3
SELECTED OU-2 UHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
903 Pad Area														
00191	Qrf	3/16/92	19		*	1.4		*	27		*	48	B	*
00191	Qrf	5/21/92	35		*	1.2		*	39		*	7.9		*
00191	Qrf	9/1/92	33		*	2		*	33		*	7		*
00491	Qc	12/18/91	52.2		*	30		*	21.9		*	55.3		*
00491	Qc	2/28/92	440		*	108		*	41		*	110		*
00491	Qc	5/20/92	500		*	113		*	30		*	114		*
00491	Qc	9/1/92	440		*	140		*	48		*	140		*
06691	Qrf	5/18/92	20000	E	*	25000	E	*	4600	E	*	110		*
06791	Qrf	5/20/92	4.1		*	0.87		*	<0.1	U	*	<0.1	U	*
06891	Qrf	5/20/92	<0.2	U	*	<0.1	U	*	<0.1	U	*	<0.1	U	*
06991	Qrf	5/18/92	5.2		*	0.4		*	41	EB	*	1.7		*
07191	Qrf	5/18/92	2.5		*	<0.1	U	*	53	EB	*	2.6		*
07291	Qc	5/20/92	<100	U	*	<50	U	*	58		*	51		*
07391	Qc	3/16/92	2300		*	1500		*	2700		*	25000	B	*
07391	Qc	5/21/92	<0.2	U	*	1700		*	690		*	5400		*
08891	Qrf	6/23/92	2300		*	450		*	14000		*	1900		*
08891	Qrf	8/31/92	17000		*	560		*	9100		*	3100		*
12991	Ka (No.1)	3/17/92	2100		*	57		*	200		*	250		*
12991	Ka (No.1)	5/22/92	1100		*	28		*	96		*	84		*
13191	Ka (No.1)	5/19/92	1800		*	740		*	48		*	3.4		*
13191	Ka (No.1)	9/2/92	1900		*	460		*	66		*	3		*
13291	Qrf	5/21/92	220		*	160		*	4.6		*	46		*
1587	Qrf	9/18/90	NA			59		V	NA			NA		
1587	Qrf	11/27/90	NA			38		V	NA			150		V
1587	Qrf	1/9/91	2500	D	V	56		V	240	E	V	160		V
1587	Qrf	4/15/91	1100		V	15	J	A	71		V	49	J	A

DRAFT

TABLE 1-3 (CONTINUED)
SELECTED OU-2 UHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
1587	Qrf	9/4/91	1600		V	19	J	A	160		V	81		V
1587	Qrf	12/18/91	NA			21		V	NA		V	110		V
1587	Qrf	2/25/92	4600		V	41	J	A	340		V	150	J	A
1587	Qrf	6/23/92	2900	D	V	33	J	A	360		V	140		V

Mound Area

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
02091	Ka (No.1)	12/14/91	1.2		*	0.64		*	72		*	56		*
02091	Ka (No.1)	2/26/92	0.6		*	0.2		*	39	E	*	28	E	*
02091	Ka (No.1)	5/15/92	0.37		*	0.71		*	11000		*	280		*
02291	Ka (No.1)	12/16/91	<0.2	U	*	3.6		*	71		*	56		*
02291	Ka (No.1)	2/26/92	<0.2	U	*	2.6		*	1900		*	340		*
02291	Ka (No.1)	5/14/92	0.45		*	3.1		*	1200	B	*	270		*
1787	Qrf	11/6/90	25		V	<5	U	V	29		V	6		V
1787	Qrf	3/9/91	24		V	<5	U	V	26		V	NA		
1787	Qrf	5/13/91	28		V	<5	U	V	25		V	7		V
1787	Qrf	8/19/91	27		V	<5	U	V	34		V	6		V
1787	Qrf	11/18/91	16		V	<5	U	V	18		V	3	J	A
1787	Qrf	2/24/92	20		V	<5	U	V	17		V	4	J	A
1787	Qrf	7/29/92	13		V	<5	U	V	12		V	21		V
1987	Qrf	8/14/91	<5	U	V	<5	U	V	880	D	JA	110		V
1987	Qrf	5/12/92	<5	U	V	1	BJ	JA	680	D	V	46		V

N.E. Trenches Area

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
02991	Ka (No.1)	3/12/92	400		*	59		*	200		*	95		*
02991	Ka (No.1)	8/21/92	560		*	28		*	170		*	88		*

DRAFT

TABLE 1-3 (CONTINUED)
SELECTED OU-2 UHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
03091	Ka (No.1)	12/14/91	58		*	3.3		*	16		*	21		*
03091	Ka (No.1)	3/5/92	174		*	3.1		*	18		*	24		*
03091	Ka (No.1)	8/19/92	450		*	3		*	33		*	51		*
03391	Ka (No.1)	12/5/91	63.4		*	12.2		*	37.5		*	54.8		*
03391	Ka (No.1)	3/13/92	170		*	12		*	77		*	33	B	*
03391	Ka (No.1)	6/2/92	450		*	14		*	208		*	74		*
03391	Ka (No.1)	7/9/92	430	D	*	13		*	240	D	*	64	D	*
03591	Qrf	12/19/91	43		*	14.8		*	27.6		*	13.9		*
03591	Qrf	3/5/92	60		*	19		*	25		*	11		*
03591	Qrf	6/4/92	1.4		*	<0.1	U	*	0.44		*	<0.1	U	*
03691	Ka (No.1)	6/8/92	5.5		*	0.2		*	3		*	0.56		*
03691	Ka (No.1)	7/8/92	410	D	*	24		*	330	D	*	56	D	*
03791	Ka (No.1)	12/6/91	68		*	28	D	*	40		*	51		*
03791	Ka (No.1)	3/19/92	700		*	43		*	350		*	140		*
03791	Ka (No.1)	7/10/92	700	D	*	23	D	*	260	D	*	100	D	*
03991	Qrf	6/23/92	23		*	0.8		*	5		*	3		*
03991	Qrf	7/8/92	13		*	0.6		*	3		*	2		*
04091	Qrf	6/24/92	3		*	1		*	0.8		*	0.4		*
05691	Qrf	12/4/91	64.5		*	11.6		*	26		*	2.1		*
05691	Qrf	3/12/92	47.1		*	4.6		*	14.5		*	20		*
05691	Qrf	5/28/92	830		*	<50	U	*	220		*	140		*
05691	Qrf	8/21/92	210		*	6		*	53		*	35		*
07891	Qrf	3/12/92	360		*	45		*	123		*	57		*
07891	Qrf	8/20/92	130		*	42		*	67		*	24		*
11491	Qrf	5/28/92	800		*	<50	U	*	120		*	110		*
11691	Ka (No.1)	12/23/91	56.3		*	23.6		*	73.2	B	*	54.7		*
11691	Ka (No.1)	3/18/92	520		*	59		*	590		*	150		*

DRAFT

TABLE 1-3 (CONTINUED)
SELECTED OU-2 UHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
11691	Ka (No.1)	7/10/92	470		*	33		*	460		*	70		*
11891	Ka (No.1)	12/19/91	58.4		*	11.3		*	70.3		*	55.4		*
11891	Ka (No.1)	2/28/92	530		*	21		*	230		*	89		*
11891	Ka (No.1)	6/2/92	580		*	14		*	180		*	71		*
11891	Ka (No.1)	7/9/92	410	D	*	12	D	*	150	D	*	51	D	*
12191	Ka (No.1)	3/16/92	240		*	7.3		*	320		*	84		*
12191	Ka (No.1)	6/3/92	400		*	10		*	310		*	53		*
12191	Ka (No.1)	8/19/92	470		*	12		*	460		*	68		*
12391	Ka (No.1)	2/12/92	6.7		*	1.5		*	0.27		*	0.4		*
12391	Ka (No.1)	5/14/92	6.6		*	2.1		*	1.1		*	1.8		*
12391	Ka (No.1)	9/15/92	5		*	1		*	0.2		*	0.3		*
12491	Ka (No.1)	2/7/92	0.5		*	8.7		*	4.9		*	3.1		*
12491	Ka (No.1)	5/14/92	5.2		*	0.82		*	2.2		*	<0.1	U	*
12491	Ka (No.1)	9/14/92	2		*	0.6		*	0.5		*	0.3		*
12691	Ka (No.1)	2/13/92	530		*	45		*	200		*	110		*
12691	Ka (No.1)	5/29/92	4500		*	160		*	1000		*	560		*
12691	Ka (No.1)	9/10/92	840		*	22		*	180		*	100		*
13391	Qrf	8/20/92	0.9		*	0.3		*	0.8		*	<0.3	U	*
2587	Ka (No.1)	11/5/90	64		V	10	J	A	280		V	48		V
2587	Ka (No.1)	3/9/91	170		V	3	J	A	330	D	V	63		V
2587	Ka (No.1)	4/22/91	130		JA	<5	U	V	330	D	V	61		V
2587	Ka (No.1)	9/10/91	<10	U	V	10	U	V	280		V	33		V
2587	Ka (No.1)	11/18/91	94		V	2	J	A	NA		V	53		V
2587	Ka (No.1)	3/3/92	65		JA	3	J	A	270		V	46		V
2587	Ka (No.1)	5/15/92	26		V	2	BJ	JA	190	D	V	28		V
3687	Ka (No.1)	3/5/90	940	J	A	1100	J	A	1100	J	A	96000		V
3687	Ka (No.1)	11/12/90	470	J	A	540	J	A	440	J	A	39000		V

DRAFT

TABLE 1-3 (CONTINUED)
SELECTED OU-2 UHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
3687	Ka (No.1)	3/8/91	770	D	V	930	D	V	610	D	V	42000	D	JA
3687	Ka (No.1)	4/19/91	800	J	JA	350		V	470		V	38000	D	V
3687	Ka (No.1)	8/23/91	870		V	840		V	770		V	68000	D	V
3687	Ka (No.1)	11/25/91	310		V	420		V	490		V	NA		
3687	Ka (No.1)	3/5/92	470		V	340		V	400		V	40000		V
3687	Ka (No.1)	5/15/92	620	DJ	A	880	BDJ	JA	520	DJ	A	40000	D	V
4286	Qrf	11/16/90	NA			14		V	170		V	80		V
4286	Qrf	3/8/91	500	D	V	19		V	120		V	340	D	V
4286	Qrf	5/17/91	420	D	V	11		V	99		V	53		V
4286	Qrf	9/11/91	660		V	15	J	A	130		V	62		V
4286	Qrf	12/4/91	NA			12		V	130		V	59		V
4286	Qrf	2/10/92	840		V	18	J	A	150		V	75		V
4286	Qrf	5/29/92	730		V	22	BJ	JA	140		V	63		V
B218789	Qrf	10/22/90	1100	E	V	16		V	NA			99		V
B218789	Qrf	5/21/91	1500	D	V	18		V	280	D	V	110		V
B218789	Qrf	8/20/91	1600	D	V	22		V	270	D	V	160		V
B218789	Qrf	11/19/91	NA			16		V	NA			97		V
B218789	Qrf	2/18/92	NA			11		V	NA			72		V
B218789	Qrf	5/8/92	890	D	V	13	B	V	170		JA	62		V
S.E. Trenches Area														
04191	Qrf	3/13/92	<0.2	U	*	8.7		*	<0.1	U	*	<0.1	U	*
04591	Qrf	12/20/91	2.4		*	0.57		*	5	B	*	0.6		*
04591	Qrf	3/3/92	4.9		*	1.2		*	9		*	0.9		*
04591	Qrf	5/22/92	4.3		*	0.49		*	5.1		*	0.62		*
04591	Qrf	8/31/92	2		*	0.6		*	5		*	0.6		*

DRAFT

TABLE 1-3 (CONCLUDED)
SELECTED OU-2 UHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
07991	Qrf	3/12/92	50		*	20		*	9		*	3.3		*
07991	Qrf	5/20/92	90		*	33		*	25		*	14		*
08091	Qrf	5/19/92	0.27		*	3.8		*	<0.1	U	*	<0.1	U	*
08391	Qrf	9/3/92	9		*	9		*	290		*	22		*
08591	Qrf	3/12/92	2.7		*	2.7		*	44		*	1.5		*

Explanation

Qc = Colluvium
Qrf = Rocky Flats Alluvium
Ka (No.1) = Arapahoe Formation Sandstone
Ka = Arapahoe Formation
cs = claystone
silt = siltstone
ss = sandstone
CCl4 = Carbon tetrachloride
CHCl3 = Chloroform
PCE = Tetrachloroethene
TCE = Trichloroethene

Analytical Codes:

A = Accepted with qualifications
B = Detected in blank sample
D = Dilution
E = Exceeded calibration range
J = Estimated value
U = Not detected
V = Validated
* = Non-Validated data
NA = Analytical result not available
ppb = parts per billion

DRAFT

TABLE 1- 4
EXISTING OU-2 LHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
903 Pad Area														
00391	Kl (ss)	12/17/91	86		*	23		*	77	B	*	34	B	*
00391	Kl (ss)'	2/28/92	890		*	36		*	180		*	130		*
00391	Kl (ss)	5/21/92	620		*	29		*	66		*	71		*
00391	Kl (ss)	9/8/92	1100		*	53		*	160		*	150		*
09691	Kl (ss)	3/18/92	59		*	24		*	91		*	2300		*
09691	Kl (ss)	5/22/92	22		*	13		*	36		*	1000		*
09691	Kl (ss)	8/31/92	120		*	<0.2	U	*	110		*	2500		*
11791	Kl (cs)	2/6/92	450	DL	*	80		*	95		*	94		*
11791	Kl (cs)	5/20/92	<0.2	U	*	0.78		*	<0.1	U	*	<0.1	U	*
11791	Kl (cs)	9/8/92	820		*	130		*	130		*	160		*
1187	Kl (ss)	9/18/90	NA			92		V	46	B	V	NA		
1187	Kl (ss)	11/28/90	660		V	86		V	41	J	A	1900		V
1187	Kl (ss)	1/15/91	750	D	JA	96		V	62		V	2500	D	JA
1187	Kl (ss)	4/16/91	400	D	V	82		V	49		JA	1400	D	V
1187	Kl (ss)	9/6/91	610		V	92		V	45		V	3300		V
1187	Kl (ss)	11/21/91	NA		V	100		V	48		V	NA		
1187	Kl (ss)	2/22/92	680		V	110	B	V	59	J	A	3300		V
1187	Kl (ss)	5/19/92	400	D	V	76	B	V	39		V	2400	D	V
1287	Kl (silt)	11/28/90	12		V	10		V	32		JA	NA		
1287	Kl (silt)	1/15/91	17		V	12		V	54		V	360	D	V

DRAFT

TABLE 1-4 (CONTINUED)
EXISTING OU-2 LHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
1287	Kl (silt)	9/11/91	<17	U	V	10	J	A	27		V	560		V
1287	Kl (silt)	11/20/91	9		V	11		V	37		V	NA		
1287	Kl (silt)	2/22/92	20		V	18		V	45		V	NA		
1287	Kl (silt)	5/18/92	17		V	16	B	V	43		V	1500	D	V
1487	Kl (ss)	11/20/90	460		V	31		V	5	J	A	140		V
1487	Kl (ss)	1/11/91	430	D	V	36		V	8		V	160	D	V
1487	Kl (ss)	4/15/91	300	D	V	27		JA	4	J	A	110		JA
1487	Kl (ss)	9/15/91	350		V	31		V	4	J	A	120		V
1487	Kl (ss)	11/21/91	440		V	41		V	6	J	A	170		V
1487	Kl (ss)	5/20/92	330	D	V	25	B	JA	4	J	A	120		V
1687	Kl (slts)	9/18/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1687	Kl (slts)	11/28/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1687	Kl (slts)	1/9/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1687	Kl (slts)	4/16/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1687	Kl (slts)	9/5/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1687	Kl (slts)	11/21/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1687	Kl (slts)	2/25/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1687	Kl (slts)	5/19/92	<5	U	V	2	BJ	JA	<5	U	V	1	J	A
3087	Kl (slts)	2/9/90	<5	U	A	<5	U	A	<5	U	A	<5	U	A
3087	Kl (slts)	10/11/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3087	Kl (slts)	3/8/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3087	Kl (slts)	5/10/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3087	Kl (slts)	8/21/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V

DRAFT

TABLE 1- 4 (CONTINUED)
EXISTING OU-2 LHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
3087	Kl (slts)	12/6/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3087	Kl (slts)	2/11/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4587	Kl (ss)	10/25/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4587	Kl (ss)	3/7/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4587	Kl (ss)	5/14/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4587	Kl (ss)	8/16/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
6286	Kl (ss)	11/21/90	4	J	A	<5	U	JA	<5	U	JA	<5	U	JA
6286	Kl (ss)	1/10/91	6		V	<5	U	V	<5	U	V	<5	U	V
6286	Kl (ss)	5/14/91	4	J	A	<5	U	V	<5	U	V	<5	U	V
6286	Kl (ss)	8/22/91	5		V	<5	U	V	<5	U	V	<5	U	V

Mound Area

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
1887	Kl (ss)	5/10/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1887	Kl (ss)	8/20/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
1887	Kl (ss)	2/25/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2087	Kl (cs)	2/9/90	<5	U	V	<5	U	V	39		V	2	J	A
2087	Kl (cs)	5/10/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2087	Kl (cs)	8/14/91	<5	U	V	<5	U	V	4	J	A	<5	U	V
2087	Kl (cs)	12/7/91	<5	U	V	<5	U	V	2	J	A	5		V
2087	Kl (cs)	2/25/92	<5	U	V	<5	U	V	6		V	3	J	A
2087	Kl (cs)	5/29/92	<5	U	V	1	BJ	JA	2	J	A	1	J	A
2287	Kl (ss)	8/14/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V

DRAFT

TABLE 1-4 (CONTINUED)
EXISTING OU-2 LHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
2287	Kl (ss)	12/12/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2287	Kl (ss)	4/24/91		U	R	<5	U	V	<5	U	V	<5	U	V
2287	Kl (ss)	6/11/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2287	Kl (ss)	10/24/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2287	Kl (ss)	1/29/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2287	Kl (ss)	4/16/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3486	Kl (ss)	10/18/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3486	Kl (ss)	3/14/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3486	Kl (ss)	4/22/91	<5	U	V	<5	U	V	2	J	A	<5	U	V
3486	Kl (ss)	10/7/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3486	Kl (ss)	1/10/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V

N.E. Trenches Area

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
46692	Kl (ss)	9/24/92	<0.1	U	*	0.5		*	<0.1	U	*	<0.3	U	*
46692	Kl (ss)	12/17/92	<0.4	U	*	<0.1	U	*	<0.2	U	*	<0.2	U	*
46792	Kl (silt)	12/16/92	<0.4	U	*	<0.1	U	*	<0.2	U	*	<0.2	U	*
46892	Kl (ss)	12/16/92	<0.4	U	*	<0.1	U	*	<0.2	U	*	<0.2	U	*
0386	Kl (ss)	11/15/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
0386	Kl (ss)	3/14/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
0386	Kl (ss)	9/11/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
0386	Kl (ss)	4/1/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
B217589	Kl (cs)	12/15/92	<0.4	U	*	<0.1	U	*	<0.2	U	*	<0.2	U	*

DRAFT

TABLE 1-4 (CONTINUED)
EXISTING OU-2 LHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
B217689	Kl (ss)	12/15/92	<0.4	U	*	<0.1	U	*	<0.2	U	*	<0.2	U	*
S.E. Trenches Area														
2887	Kl (slts)	11/28/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2887	Kl (slts)	1/15/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2887	Kl (slts)	4/16/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2887	Kl (slts)	9/5/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2887	Kl (slts)	11/22/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
2887	Kl (slts)	2/25/92	<5	U	V	<5	U	V	<5	U	V	1	J	A
2887	Kl (slts)	5/21/92	<5	U	V	1	BJ	JA	<5	U	V	<5	U	V
3187	Kl (ss)	11/21/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3187	Kl (ss)	1/11/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3187	Kl (ss)	4/16/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3187	Kl (ss)	9/10/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3187	Kl (ss)	11/21/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3187	Kl (ss)	2/27/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3187	Kl (ss)	5/19/92	<5	U	V	1	BJ	JA	<5	U	V	<5	U	V
3487	Kl (slts)	9/18/90	7		V	<5	U	V	4	BJ	JA	1	J	A
3487	Kl (slts)	11/28/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3487	Kl (slts)	1/15/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3487	Kl (slts)	4/16/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3487	Kl (slts)	9/5/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V

DRAFT

TABLE 1-4 (CONCLUDED)
EXISTING OU-2 LHSU WELLS
GROUNDWATER ANALYTICAL RESULTS FOR CHLORINATED HYDROCARBONS

Well Number	Geological Strat. of Completion	Collection Date	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
3487	Kl (slts)	11/20/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3487	Kl (slts)	2/27/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
3487	Kl (slts)	5/19/92	<5	U	V	1	BJ	JA	<5	U	V	<5	U	V
4086	Kl (cs)	11/28/90	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4086	Kl (cs)	1/11/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4086	Kl (cs)	4/16/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4086	Kl (cs)	11/20/91	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4086	Kl (cs)	2/27/92	<5	U	V	<5	U	V	<5	U	V	<5	U	V
4086	Kl (cs)	5/19/92	<5	U	V	1	BJ	JA	<5	U	V	<5	U	V
B217789	Kl (cs)	12/15/92	<0.4	U	*	<0.1	U	*	<0.2	U	*	<0.2	U	*

Explanation

cs = claystone
silt = siltstone
ss = sandstone
Kl = Laramie Formation

CCl4 = Carbon Tetrachloride
CHCl3 = Chloroform
PCE = Tetrachloroethene
TCE = Trichloroethene

Analytical Validation Codes:

A = Accepted with qualifications
B = Detected in blank sample
D = Dilution
E = Exceeded calibration range
J = Estimated value

U = Not detected
V = Validated
NA = Analytical result not available
* = Non-Validated Data
ppb = parts per billion

DRAFT

The alluvial/colluvial isoconcentration map (Figure 1-25) was constructed using groundwater analytical results from alluvial and colluvial wells from first quarter 1992. This sampling period was selected because it includes data from wells installed during the Phase II field investigation and represents the most complete water quality data set available. In the immediate vicinity of the 903 Pad, second quarter 1992 data were also utilized to incorporate data from wells in that area that were not available for first quarter 1992. In addition to the water quality data, the estimated lateral extent of CCl_4 contamination in groundwater in the alluvium took into consideration data for the lateral extent of saturated alluvium for the first quarter of 1992. The Arapahoe No. 1 Sandstone isoconcentration map (Figure 1-26) was constructed using groundwater analytical results from wells completed in the No. 1 Sandstone from the first quarter 1992. The estimated lateral extent of CCl_4 contamination in groundwater in the No. 1 Sandstone also took into consideration data on the lateral extent of the No. 1 Sandstone within OU-2. In addition, first quarter 1992 data for LHSU Wells 1187, 1287, 09691, 00391, and 11791 (Table 1-4) were used in developing the CCl_4 concentration contours shown on Figures 1-25 and 1-26 because the CCl_4 concentrations detected in groundwater samples from those wells are believed to be indicative of contaminant concentrations in the colluvium, rather than wider spread contamination in the LHSU sandstones, as discussed later in this section.

Analytical results obtained from surface water contact seep locations were also utilized to assist in the CCl_4 plume definition (EG&G 1991b). In addition, UHSU groundwater potentiometric surface maps were used to evaluate groundwater flow and contaminant migration directions (Figures 1-11 and 1-12).

Based on a review of the contamination results illustrated in Figures 1-25 and 1-26, it appears that six substantial CCl_4 hotspots are present in the UHSU. Figure 1-25 shows a CCl_4 hotspot in the alluvium beneath the 903 pad. This hotspot is based on second quarter 1992 data for Well 08891 which indicate a CCl_4 concentration of 2,300 ppb at that location. Another CCl_4 hotspot is located just east of the 903 Pad with a maximum concentration of 4,600 ppb at Well 1587. CCl_4 plumes from this hotspot, which overlies an alluvial groundwater flow divide as shown on Figure 1-11, extend northeastward along the flow path coincident with the main scour channel, and southward toward Woman Creek. Two other hotspots shown on Figure 1-25 occur in the colluvium along the north slope of the Woman Creek drainage. Plumes from these hotspots extend southward toward Woman Creek. One is located in the vicinity of the Trench T-2 Site (IHSS No. 109) and has a maximum concentration of 2,300 ppb at Well 07391. Another is located east of that location and has a maximum concentration of 890 ppb at LHSU Well 00391. Because no source is immediately adjacent to the hotspot associated with Well

00391, it is believed to be related to seepage of contaminated groundwater from the subcropping No. 1 Sandstone into the colluvium in that area.

Figure 1-26 shows two CCl_4 hotspots in the No. 1 Sandstone. One is located along the north slope of the Woman Creek drainage valley and is coincident with and believed to be the source of the colluvial hotspot discussed above (i.e., the hotspot associated with Well 00391). This No. 1 Sandstone hotspot has a maximum CCl_4 concentration of 2,100 ppb at Well 12991. The plume from this hotspot extends southward toward Woman Creek and is believed to discharge to the colluvium at a seep where the No. 1 Sandstone subcrops beneath the colluvium.

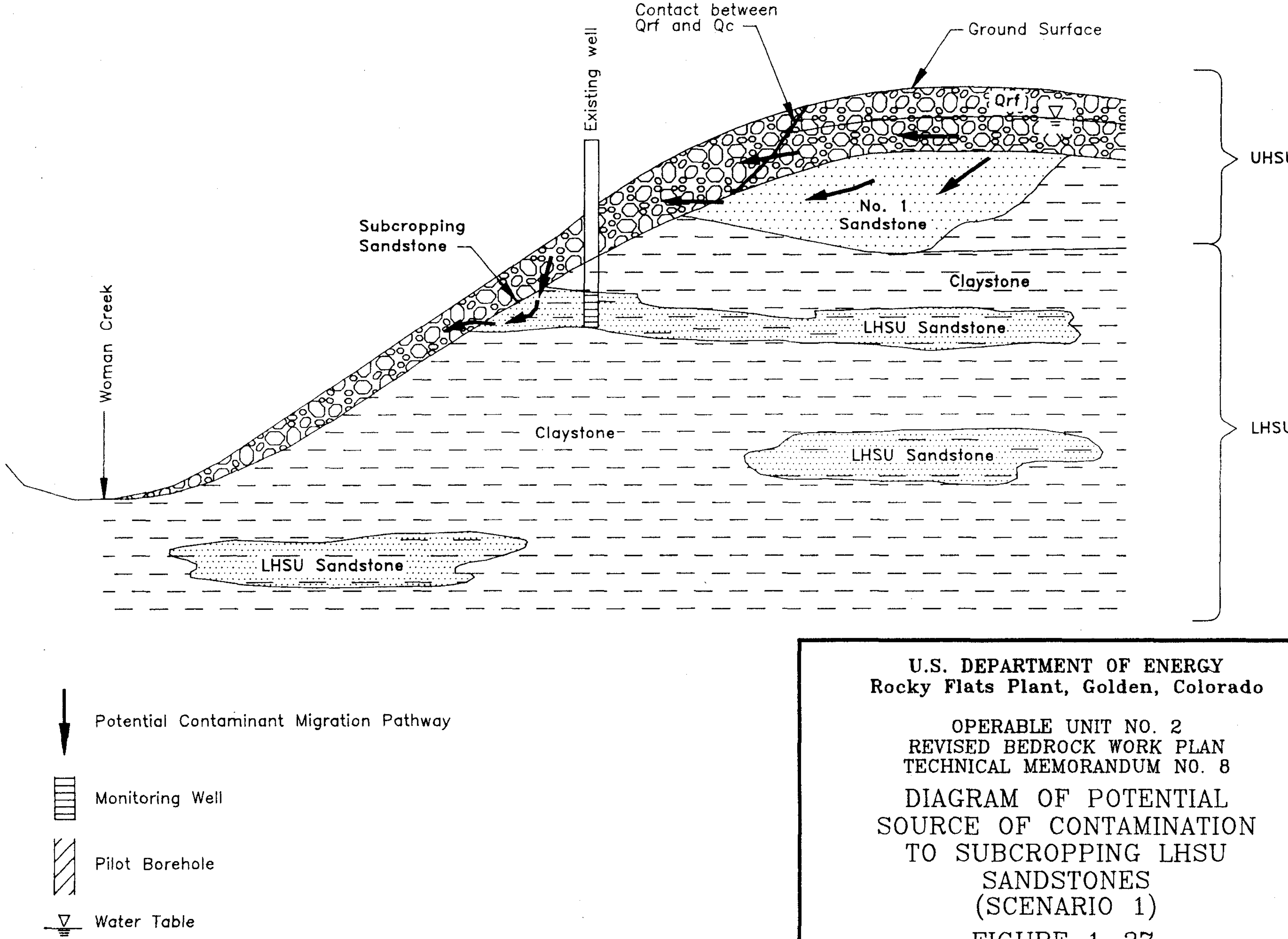
The second No. 1 Sandstone hotspot is located just north of the Northeast Trenches Area. It has a maximum CCl_4 concentration of 700 ppb at Well 03791. The plume from this hotspot extends northward toward South Walnut Creek where the No. 1 Sandstone subcrops along the south slope of the South Walnut Creek drainage valley.

Potential Contamination Sources to LHSU

With the exception of IHSS No. 109, all IHSS's in OU-2 are located within the unconsolidated material of the UHSU. IHSS No. 109 is partially in unconsolidated UHSU colluvial material and partially in consolidated LHSU claystone. There are no source areas located directly in LHSU sandstones or siltstones. Therefore, potential contamination sources to the LHSU sandstones or siltstones are believed to be limited to secondary groundwater plume sources within the UHSU.

Two potential scenarios for migration of groundwater contamination from the UHSU to LHSU have been suggested. Figures 1-27 and 1-28 diagrammatically illustrate these two mechanisms. Figure 1-27 illustrates a scenario (scenario 1) in which contaminants in the UHSU alluvium or No. 1 Sandstone migrate laterally to discharge points beneath the colluvium along the drainage slope for Woman Creek, and then migrate downslope within the colluvium to locations where LHSU sandstones subcrop beneath the colluvium. The contaminated colluvial water then locally recharges the LHSU sandstones at the subcrop locations, resulting in contamination in the LHSU sandstone wells located near the subcrops. It is expected that LHSU contamination resulting from this scenario will be limited to the vicinity of the subcrops because the lateral hydraulic gradient within the LHSU sandstones should be toward the drainage, rather than back into the hill. Thus, contamination locally entering the sandstones at the subcrops should be discharged relatively quickly back into the colluvium.

3047E03



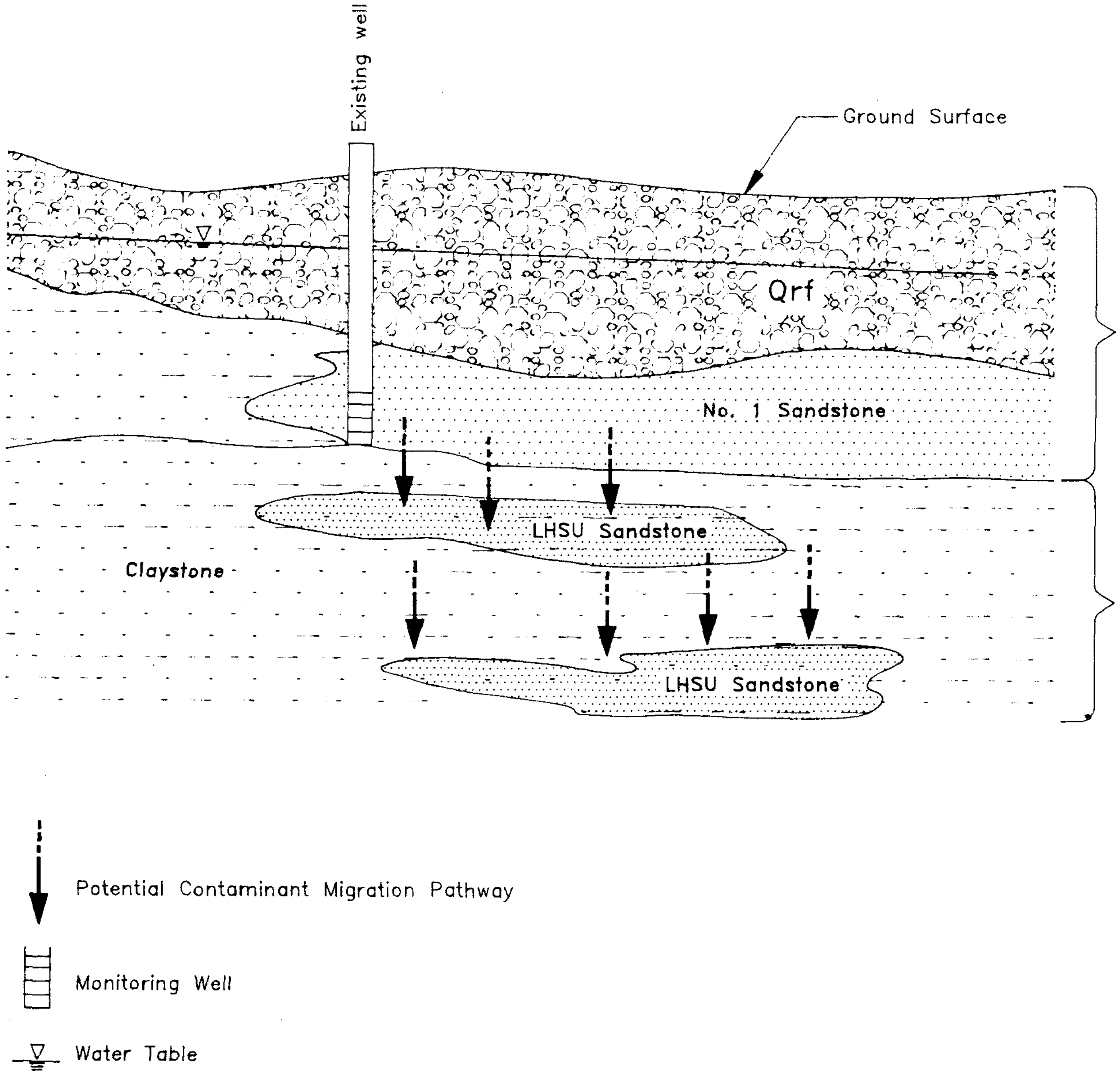
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DIAGRAM OF POTENTIAL SOURCE OF CONTAMINATION TO SUBCROPPING LHSU SANDSTONES (SCENARIO 1)

FIGURE 1-27

MARCH 1993



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DIAGRAM OF POTENTIAL VERTICAL MIGRATION OF CONTAMINANTS FROM UHSU TO LHSU (SCENARIO 2)

FIGURE 1-28

MARCH 1993

3047E04

Figure 1-28 illustrates a second scenario (scenario 2) in which contaminated UHSU groundwater migrates vertically from the UHSU to the LHSU where underlying LHSU sandstones are in close vertical proximity to the UHSU. Under this scenario, contaminants migrate vertically downward with groundwater in response to a downward vertical hydraulic gradient between the UHSU and LHSU. Once in the LHSU sandstone unit, the contaminants may migrate laterally within the sandstone or vertically to deeper LHSU units.

Of the two scenarios, scenario 2 is of the most concern with regard to the LHSU because it represents the one which is potentially associated with a LHSU exposure pathway. Scenario 1 is of less concern with regard to a potential LHSU exposure pathway because it is believed to be associated with an UHSU exposure pathway (i.e., migration of contaminants through the colluvium). Potential exposure pathways for the LHSU are discussed in Section 1.2.1.3.

Based on available data for OU-2, it appears that scenario 1 is likely and scenario 2 is unlikely, as discussed below. The SAP (Section 2) describes investigation activities to evaluate further the potential for these scenarios.

The following paragraphs discuss identified contamination in the LHSU based on data from previous investigations. Where applicable, the identified LHSU contamination locations are discussed relative to the LHSU contaminant source mechanism scenarios discussed above.

Identified LHSU Contamination

Identification of potential CHC contamination in the LHSU was based on a review of groundwater and LHSU bedrock material analytical results from the OU-2 Phase I, Seismic, and Phase II Investigations. There are a total of 30 wells located in OU-2 that are believed to be screened in the LHSU and a total of 11 boreholes in which samples of LHSU bedrock were collected at depths of greater than six feet below the UHSU/LHSU contact. Groundwater analytical results are available for 26 of the LHSU wells, and bedrock analytical results are available for all 11 of the boreholes. Validated groundwater analytical results collected since 1990 from the Phase I investigation and all available non-validated results obtained from the Phase II and Seismic Investigation wells were reviewed. The groundwater analytical results and stratigraphy of the screened intervals are listed in Table 1-4. The highest concentrations of CCl_4, PCE, and TCE detected in groundwater since 1990 are shown on Figure 1-29.

LHSU bedrock material samples obtained at depths of six feet or greater below the UHSU/LHSU contact were also reviewed and are listed in Table 1-5. In addition to the results

TABLE 1-5
SELECTED OU-2 BOREHOLES
LHSU BEDROCK ANALYTICAL RESULTS
CHLORINATED HYDROCARBONS

Well Number	Sample Number	Geological Strat. of Completion	Depth to Base of UHSU (ft.)	Depth below UHSU/LHSU Contact (ft.)	Depth to Top of Sample (ft.)	Depth to Bottom of Sample (ft.)	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
903 Pad Area																		
07391	BH00479WCU2	Qc\Kl (cs)	8.1	7.7	15.8	16.0	<11	U	V	4	J		<11	U	V	290		V
09291	BH01272WCU2	Kl (cs)	1.6	1.9	3.5	3.7	<6	U	V	<6	U		<6	U	V	<6	U	V
09291	BH01273WCU2	Kl (cs)	1.6	6.0	7.6	7.8	<6	U	V	<6	U		<6	U	V	40		V
09691	BH01213WCU2	Kl (cs)	12.1	7.5	19.6	19.8	<6	U	V	<6	U		<6	U	V	1	J	A
09791	BH01222WCU2	Kl (cs)	13.2	6.9	20.1	20.3	49		V	5	J		14		V	12		V
11791	BH00028WCU2	Kl (cs)	6.9	6.7	13.6	13.8	10		V	<6	U		<6	U	V	<6	U	V
BH2587	BH258718BR	Kl (cs)	14.8	3.7	18.50	19.30	<25	U		<130	U		3800			16000		
BH2587	BH258720WS	Kl (cs)	14.8	4.9	19.70	20.50	<250	U		<250	U		2100			13000		
Mound Area																		
09991	BH00358WCU2	Kl (cs)	13.1	2.5	15.6	15.8	<6	U		<6	U		48			7		
09991	BH00359WCU2	Kl (cs)	13.1	4.5	17.6	17.8	<6	U		<6	U		100			20		
09991	BH00360WCU2	Kl (cs)	13.1	6.5	19.6	19.8	<6	U		<6	U		180			19		
N.E. Trenches Area																		
12391	BH00146WCU2	Kl (No.2)	65.7	9.6	75.3	75.5	<6	U	JA	<5	U		<6	U	JA	<6	U	JA
12391	BH00147WCU2	Kl (No.2)	65.7	9.9	75.6	75.8	<5	U	JA	<6	U		<5	U	JA	<5	U	JA
12491	BH00068WCU2	Kl (No.2)	58	6.8	64.8	65.0	<6	U	V	<6	U		<6	U	V	<6	U	V
OB20191	BH00585WCU2	Kl (cs)	57	6.8	63.8	64.0	<6	U	V	<6	U		<6	U	V	<6	U	V

DRAFT

TABLE 1-5 (CONCLUDED)
SELECTED OU-2 BOREHOLES
LHSU BEDROCK ANALYTICAL RESULTS
CHLORINATED HYDROCARBONS

Well Number	Sample Number	Geological Strat. of Completion	Depth to Base of UHSU (ft.)	Depth below UHSU/LHSU Contact (ft.)	Depth to Top of Sample (ft.)	Depth to Bottom of Sample (ft.)	CCl4 (ppb)	Lab Qualifier	Validation Qualifier	CHCl3 (ppb)	Lab Qualifier	Validation Qualifier	PCE (ppb)	Lab Qualifier	Validation Qualifier	TCE (ppb)	Lab Qualifier	Validation Qualifier
S.E. Trenches Area																		
BH[illegible]287	BH528724BR	Kl (cs)	17	7.0	24.00	25.00	<25	U		<25	U		<25	U		<25	U	

Explanation

Qc = Colluvium

Qrf = Rocky Flats Alluvium

Ka (No.1) = Arapahoe Formation Sandstone

Kl (cs) = Laramine Formation Claystone

Kl (No.2) = Laramine Formation Sandstone

Kl (silt) = Laramine Formation Siltstone

CCl4 = Carbon tetrachloride

CHCl3 = Chloroform

PCE = Tetrachloroethene

TCE = Trichloroethene

Analytical Codes:

A = Accepted with qualifications

B = Detected in blank sample

D = Dilution

E = Exceeded calibration range

J = Estimated value

U = Not detected

V = Validated

* = non- validated data

NA = Analytical result not available

ppb = parts per billion

DRAFT

currently available for review, groundwater analytical results are pending for samples collected during the fourth quarter of 1992 from Seismic Investigation Wells B315289, B317189, B217289, and B217489.

Based on review of the available data, CHC contamination in groundwater in the LHSU appears to be limited. CHCs have been detected in groundwater samples from 10 out of 26 monitoring wells believed to be screened in the LHSU for which data are available since 1990. However, of those 10 wells, seven are located on the north slope of the Woman Creek drainage, and are screened in LHSU sandstones near where they subcrop beneath the colluvium. These wells, which have the most consistent and highest concentration CHC detections observed in the LHSU, are believed to be representative of the mechanism described by scenario 1 above (Figure 1-29). That is, the CHCs detected in the samples from the wells are believed to be indicative of localized contamination related to recharge of contaminated colluvial water near the subcrops, rather than wider spread contamination in the LHSU sandstones. If so, migration of contamination is associated with an UHSU exposure pathway through the colluvium, rather than a LHSU exposure pathway through the LHSU sandstone units. The other three LHSU wells which have had CHC detections are located in the central portion of the OU-2 plateau, and have had generally minor level detections of CHCs in the low parts per billion range. These wells are believed to be representative of the vertical contaminant migration mechanism described by scenario 2 above.

The LHSU wells located along the north slope of the Woman Creek drainage (Figure 1-29, scenario 1 type) consist of Wells 1187, 1287, 1487, 09691, 6286, 00391, and 11791. Groundwater samples from Wells 1187, 1287, 1487, and 09691 have contained concentrations of CCl_4 ranging from 9 to 750 ppb, PCE ranging from 4 to 110 ppb, chloroform ranging from below detection to 110 ppb, and TCE ranging from 110 ppb to 3,300 ppb. Groundwater samples from Well 6286 have periodically (four out of six sampling events) contained CCl_4 at concentrations (4 to 6 ppb) near the method detection limit, but have not contained PCE, TCE, or chloroform. Samples from Wells 00391 and 11791 have contained concentrations of CCl_4 ranging from below detection to 1,100 ppb, PCE ranging from below detection to 180 ppb, chloroform ranging from 0.78 to 130 ppb, and TCE ranging from below detection to 160 ppb. As discussed above, it is believed that the CHC concentrations detected in these wells are more representative of colluvial water contamination and an UHSU exposure pathway than they are of LHSU contamination related to a LHSU exposure pathway.

Migration of UHSU CHC contaminants to the LHSU via the vertical migration mechanism described in scenario 2 above, is less evident based on the available data for wells located in the central portion of the OU-2 plateau (i.e., away from the slopes and subcrops). Those wells consist of Wells 2087, 3487, and 2887 (Figure 1-29, scenario 2 type). CHCs have been detected in samples from those wells, but usually at concentrations near the method detection limits. In many cases, the detected CHCs have also been detected in laboratory blanks, indicating possible laboratory-related contamination of the samples. TCE and PCE have been detected in samples from Well 2087 in four and five of the six sampling events, respectively, but have been at levels (1 to 6 ppb) near the method detection limits (a detection of PCE at a concentration of 39 ppb occurred once in Well 2087). Chloroform was detected once in Well 2087 at 1 ppb. Well 3487, screened in a LHSU siltstone, has been sampled eight times, but has had CHCs (CCl_4, chloroform, PCE, and TCE) detected only twice, and always at concentrations (1 to 7 ppb) near the method detection limits. Of the seven sampling events conducted in Well 2887, chloroform and TCE have each been detected once, both at concentrations of 1 ppb.

LHSU bedrock samples obtained at depths greater than six feet below the UHSU/LHSU contact indicate no substantial CHC contamination, with the exception of Boreholes BH2587 and 09991, as shown in Figures 1-30 and 1-31. Borehole BH2587 is located in IHSS No. 109, Trench T-2, south of the 903 Pad. Analytical results for LHSU claystone samples obtained from BH2587 at a depth of 19.7 to 20.5 feet (the deepest samples collected from the boring) exhibit levels of TCE and PCE at 13,000 ppb and 2,100 ppb, respectively. Borehole 09991 is located in IHSS No. 113, Mound Site. Analytical results for LHSU claystone samples obtained from 09991 at a depth of 19.6 to 19.8 feet (also the deepest samples from that boring) also indicated the presence of TCE (19 ppb) and PCE (180 ppb). Both boreholes are completed in LHSU claystones which are not expected to readily transmit groundwater. Samples from five other LHSU borings did not contain CHCs at levels above the method detection limits.

To summarize, groundwater contamination detected in the LHSU appears to be limited to the subcrop areas along Woman Creek and to a few locations in the central portion of OU-2. Where it occurs along the slopes of Woman Creek, it is likely localized in the vicinity of the subcrop locations and related to localized recharge of contaminated colluvial water to the LHSU sandstones (scenario 1 type). If so, this contamination is associated with a potential UHSU exposure pathway in the colluvium, rather than a LHSU exposure pathway. Where contamination has been detected in the LHSU in the central portion of OU-2, it may be associated with a potential LHSU exposure pathway. However, contamination in these areas has generally been detected at low concentrations near the method detection limits and may, in some cases, be representative of laboratory contamination of the samples. Field activities are specified in the SAP (Section 2) to evaluate the source of contaminants identified in subcropping LHSU sandstones (scenario 1 type), and to assess the potential for vertical migration of UHSU contaminants to the LHSU (scenario 2 type).

CHCs have been detected in LHSU bedrock claystone materials in two locations out of 11 where samples have been collected. Field activities are specified in the SAP (Section 2) to evaluate the vertical extent of the CHC contamination in claystone at the two borehole locations where it was detected.

1.2.1.3 <u>Conceptual Site Model</u>

An integral part of the DQO process is the development of a Conceptual Site Model (CSM) to identify and describe pathways by which receptor populations may be potentially exposed to chemicals of concern. An exposure pathway describes a specific environmental pathway by which an individual can be exposed to chemical constituents present at or originating from a site. A complete exposure pathway includes five necessary elements:

- A source of chemicals
- A mechanism of chemical release
- An environmental transport medium
- An exposure point
- A human intake route

Each one of these five elements must be present for an exposure pathway to be complete. An incomplete exposure pathway means that no human exposure can occur. Only potentially complete and relevant pathways will be addressed in the Human Health Risk Assessment for OU-2.

The CSM for OU-2 is shown on Figure 1-32. The CSM is a schematic representation of the chemical source areas, chemical release mechanisms, environmental transport media, potential human intake routes, and potential human receptors. The purpose of the CSM is to provide a framework for problem definition, to identify exposure pathways that may result in human health risks, to aid in identifying data gaps, and to aid in identifying effective cleanup measures, if necessary, that are targeted at significant contaminant sources and exposure pathways. A detailed discussion of the CSM for OU-2 is presented in the Human Health Risk Assessment Exposure Scenarios Technical Memorandum No. 5 (DOE 1992a). The discussion presented herein focuses on the potential exposure scenarios associated with the LHSU.

In the CSM (Figure 1-32), potentially complete and relatively significant exposure pathways are designated by an "S". Potentially complete and relatively insignificant exposure pathways are designated by an "I". Negligible or incomplete exposure pathways are designated by an "N". For the OU-2 Human Health Risk Assessment, only exposure pathways designated by an "S" or "I" will be quantitatively evaluated. Those designated by an "N" will not be quantitatively evaluated.

Potentially exposed human receptors for LHSU groundwater include a future on-site ecological researcher and hypothetical off-site resident (from exposure to contaminated surface water/ suspended sediment if contaminated LHSU groundwater were to discharge at a seep), and a hypothetical on-site resident from exposure to contaminated surface water/sediment or groundwater from a well. As shown on Figure 1-32, potential exposure pathways associated with the LHSU have been designated as "N" because they are believed to be incomplete. This designation is based on existing data presented above which indicate that LHSU contamination associated with potential LHSU exposure pathways (i.e., scenario 2 type) is limited. In addition, due to the low permeability (Table 1-2) and discontinuous nature of the LHSU sandstones (Figures 1-15 through 1-23), it appears that there is no viable migration pathway in the LHSU for contaminants to reach ground surface, nor is there sufficient well production capability in the LHSU sandstones to support a water supply for on-site residents. In other words, three of the five necessary elements for a complete exposure pathway described previously; a source of chemicals, an environmental transport medium, and a mechanism of release, are not present. Therefore, the LHSU exposure pathway is incomplete. Because only potentially complete (designated by an "S") and relatively insignificant (designated by an "I") exposure pathways will be quantitatively evaluated in the OU-2 RFI/RI (Figure 1-32), no quantitative analysis of human health risk is necessary for the LHSU.

As noted previously, LHSU contamination detected in LHSU wells along the slope of Woman Creek (scenario 1 type) is believed to be associated with an UHSU exposure pathway through the colluvium. As shown on Figure 1-32, UHSU groundwater exposure pathways will be quantitatively evaluated in the OU-2 RFI/RI Report.

To assess the validity of the assumption that the LHSU exposure pathway is incomplete, this Revised Bedrock Work Plan incorporates field investigation activities described in the SAP (Section 2.0) to investigate the most likely areas for LHSU contamination, and to evaluate the permeability of LHSU units in those areas. Based on the results of the work described in the SAP, one of two conclusions will be reached. If the results of the field investigation confirm with sufficient certainty that the exposure pathway through the LHSU is incomplete, that conclusion will be presented in the RFI/RI Report, and no quantitative analysis of human health risk will be performed for the LHSU pathways shown on Figure 1-32. If the results of the field program fail to support the assumption that the LHSU exposure pathway is incomplete, then a quantitative evaluation of human health risk through exposure pathways in the LHSU may be required. In that event, additional data may have to be gathered as part of a second LHSU field investigation to support the quantitative assessment of human health risk through exposure pathways in the LHSU.

1.2.1.4 <u>Objective of Revised Bedrock Work Plan</u>

The objective of the Revised Bedrock Work Plan is to gather data necessary to sufficiently verify the assumption that no complete exposure pathway exists in the LHSU. To accomplish this, it is necessary to evaluate the following:

- The presence or absence of contamination in LHSU units, and if present, the source, nature, and vertical extent of contaminants in the LHSU.

- The permeability of LHSU units containing contamination to evaluate whether viable migration pathways to human receptors exist, or if the LHSU units have sufficient well production capability to supply an on-site resident.

The SAP describes field activities to acquire data for the following purposes:

- Evaluate LHSU groundwater quality in areas with the highest potential for LHSU contamination (i.e., beneath areas where high levels of contamination are present in the UHSU and where the potential for hydraulic communication between the UHSU and LHSU is greatest).

- Investigate source and vertical extent of contamination in LHSU where contamination has been detected previously (e.g., in LHSU sandstone units which subcrop beneath the colluvium).

- Estimate permeability of LHSU units containing contamination to evaluate potential for migration of contaminants within LHSU, or potential for contaminated LHSU units to supply sufficient water for an on-site residential water supply.

1.2.2 Stage 2 - Data Uses/Needs

Stage 2 of the DQO process involves the identification of data uses and types as well as data quality and quantity needs to meet the objectives specified in Stage 1. It also includes the selection of the sampling approach and analytical options for the task. Finally DQOs must address the precision, accuracy, representativeness, comparability, and completeness (PARCC) parameters of the planned activities (EPA 1987).

1.2.2.1 Data Uses

To address the objectives outlined during Stage 1 of the DQO process, the anticipated uses for the collected data must be specifically stated. The data from the Revised Bedrock Work Plan field investigation will be used to assess whether significant contamination exists in the LHSU, and, if it exists, evaluate the source and vertical extent of the contamination. Additionally, data will be used to estimate the permeability of LHSU units containing contamination to evaluate the potential for migration of contaminants in the LHSU, and evaluate the potential for contaminated LHSU units to supply sufficient water for an on-site residential water supply. The results of the evaluations will then be used to assess whether a complete exposure pathway exists within the LHSU, and whether a quantitative assessment of human health risk is necessary for that pathway.

1.2.2.2 Data Types

Upon identification of the intended users and use of the data to be collected, the specific data types needed can be developed. Data types include general categories such as water quality data and groundwater level data, as well as more specific information such as proposed analytical parameters. The analytical requirements are dictated by the intended use of the data (EPA 1987).

Specific data types to be collected during implementation of the Revised Bedrock Work Plan field investigation include:

- Stratigraphic data (e.g., depth, thickness, texture of LHSU lithologic units) on the occurrence, nature, and distribution of LHSU geologic units within OU-2 (from lithologic logs prepared during drilling and the results of borehole geophysical logging).

- Hydrogeologic data on the presence of water bearing units in the LHSU and groundwater levels in those units (from drilling observations and water level measurements in newly-completed LHSU monitoring wells).

- Geotechnical data on properties (e.g., porosity, density) of LHSU geologic units (from analysis of geotechnical samples and the results of borehole geophysical logging).

- Data on permeability of LHSU sandstone units (from observations during well development, laboratory geotechnical analysis, and data collected during slug testing of newly-installed LHSU monitoring wells).

- Groundwater chemical data for LHSU sandstone units (from analysis of samples collected from each newly-installed LHSU monitoring well).

- Chemical data for LHSU claystone units (from analysis of claystone samples collected from two source boreholes).

1.2.2.3 Data Quality

Analytical methods and support levels must be evaluated during development of site-specific DQOs. The parameters for which the analytical method is valid, its limitations, and any special considerations that will affect data quality must be understood in order to select appropriate analytical methods for specific uses.

The analytical options available to support data collection activities are presented in five general levels (EPA 1987). These levels are distinguished by the types of technology and documentation used, and their degree of sophistication.

- LEVEL V - Nonstandard methods. Radiological analyses and analyses that may require method modification and/or development. These data can be used for risk assessment applications.

- LEVEL IV - Contract Laboratory Program (CLP) Routine Analytical Services (RAS). This level is characterized by rigorous QA/QC protocol and documentation and provides qualitative and quantitative analytical data. These data can be used for risk assessment applications.

- LEVEL III - Laboratory analysis using methods other than CLP RAS. This level is used primarily to support engineering studies and risk assessments using standard EPA-approved procedures. Some procedures may be equivalent to CLP RAS without CLP requirements for documentation.

- LEVEL II - This level is characterized by the use of portable analytical instruments which can be used on site, or in mobile laboratories stationed near a site. This level is appropriate for determining the presence of contaminants, relative concentrations, and screening of samples.

- LEVEL I - This level is characterized by the use of portable instruments which can provide real-time data to assist in the optimization of sampling point locations.

A full discussion of the analytical parameters selected for the Revised Bedrock Work Plan and the rationale for selection of those parameters is provided in the SAP (Section 2.7). The analytical methods to be utilized are summarized in Table 2-9 of Section 2.

Chemistry data derived from the Revised Bedrock Work Plan field investigation will be used for a number of purposes:

- Initial screening of LHSU bedrock core samples using an organic vapor analyzer (OVA) and a field radiological detector to aid in selecting samples for laboratory analysis for LHSU contamination characterization or drill cuttings characterization.

- Laboratory analysis of LHSU claystone samples from source boreholes for the LHSU parameter analytical suite (Section 2.7.4.2) to evaluate the vertical extent of contamination in those areas.

- Laboratory analysis of groundwater samples for a selected suite of indicator parameters (Section 2.7.4.1) to evaluate the presence or absence of contamination in LHSU units.

- Laboratory analysis of groundwater samples for the LHSU parameter analytical suite to confirm the results based on indicator parameters and to fully characterize the range of contaminants present at a particular location in the LHSU, if contaminants are present.

Initial screening of LHSU bedrock core samples using an OVA and field radiological detector will be performed in accordance with LEVEL 1 analytical requirements. The OVA and radiological analyses will be used for field screening purposes only.

Laboratory analysis of LHSU claystone bedrock samples from source boreholes for the LHSU parameter analytical suite (with the exception of radionuclides) will be performed in accordance with LEVEL IV analytical procedures and reporting requirements to allow for full data validation, and to be consistent with LHSU claystone sample analytical results obtained previously. Laboratory analysis of claystone samples for radionuclides are considered non-standard laboratory analyses; therefore, the analytical level for these constituents in Level V (EPA 1987).

Laboratory analysis of groundwater samples for indicator parameters will be conducted in accordance with LEVEL III analytical procedures and reporting requirements. The sole purpose of these analyses is to provide a preliminary screening for the presence or absence of contamination in a particular LHSU unit.

Laboratory analysis of groundwater samples for the LHSU parameter analytical suite (with the exception of radionuclides) will be performed in accordance with LEVEL IV analytical procedures and reporting requirements to allow for full data validation, and to be consistent with LHSU groundwater sample analytical results obtained previously. Laboratory analyses of groundwater for radionuclides are considered nonstandard laboratory analyses; therefore, the analytical level for these constituents is LEVEL V (EPA 1987).

1.2.2.4 Data Quantity

The number of samples to be collected during implementation of the Revised Bedrock Work Plan field investigation program is discussed in the SAP (Section 2.7).

1.2.2.5 PARCC Parameters

The PARCC parameters are indicators of data quality. Precision is a quantitative measurement of the reproducibility of the data under a given set of conditions and may be determined by collecting field duplicate (replicate) samples. Accuracy measures the bias in a sampling program, and can be assessed through the collection and analysis of field and trip blanks. Analytical accuracy is evaluated through the analysis of laboratory Quality Assurance/Quality Control (QA/QC) samples and matrix spikes. The degree to which a data set is representative of the study area is know as representativeness. This criterion is best addressed by ensuring that the SAP justifies the sampling locations and that a sufficient number of samples are collected. Completeness is defined as the percentage of valid measurements and comparability is a qualitative indicator of how well newly collected data will be comparable with previously collected data. PARCC parameters for the Revised Bedrock Work Plan are discussed in Section 3.0.

1.2.3 Stage 3 - Design Data Collection Program

Stage 3 results in the description of the procedures that will be implemented to obtain data of acceptable quality and quantity to make the required decisions. Through the process of addressing the elements identified in Stages 1 and 2, all the components required for completion of Stage 3 should be available. The SAP presented in Section 2.0 describes the data collection program for the Revised Bedrock Work Plan. The SAP describes the protocols for sample collection including the types and locations of samples to be collected. Section 3.0 presents QA/QC considerations.

2.0
SAMPLING AND ANALYSIS PLAN

This section provides a description of the Sampling and Analysis Plan to be implemented for the Revised Bedrock Work Plan field investigation program. The purpose of this section of the technical memorandum is to provide a SAP that will address the data needs and describe the work required to fulfill the data quality objectives discussed in Section 1.0.

2.1 OBJECTIVES AND APPROACH

The goals of the Revised Bedrock Work Plan field investigation program are to: 1) evaluate the presence or absence of contamination in LHSU units, and if present, the source, nature, and vertical extent of contaminants in the LHSU, and 2) estimate the permeability of LHSU units containing contamination to evaluate whether viable migration pathways to human receptors exist, or if the LHSU units have sufficient well production capability to supply an on-site resident. As discussed in Section 1.0, this field investigation program is a refinement of the program previously described in the Bedrock Work Plan (EG&G 1991e).

The Revised Bedrock Work Plan field investigation program focuses on gathering data to sufficiently verify the assumption that substantial LHSU contamination associated with potential LHSU exposure pathways does not exist, or that, if present, the contamination does not pose a risk to human health because the exposure pathway in the LHSU is incomplete. It is believed that this approach is appropriate because, as discussed in Section 1.2, data collected to date indicate that the potential for migration of contaminants from the UHSU to the LHSU, as well as the potential for migration of contaminants within the LHSU, appears to be limited. Additionally, based on the low permeability of LHSU units, it appears that development of an on-site domestic water supply from the LHSU is infeasible. However, the Revised Bedrock Work Plan field program does have the limitation that it does not contain provisions for characterizing the lateral extent of contamination in the LHSU if: 1) the results of the investigation indicate that substantial contamination is present, and 2) there is unacceptable uncertainty with regard to whether a complete exposure pathway to human receptors exists. In the event that the results of the field investigation program contradict the assumed conditions, additional field investigations to characterize the nature and extent of LHSU contamination, and evaluate the potential for human health risk may be required. The approach described herein is proposed because it is believed that the potential for human health risk is greatest for the

UHSU. This approach will allow completion of the RFI/RI in a timely manner so as to address that potential as expediently as possible.

The Revised Bedrock Work Plan field investigation program is designed to incorporate an observational approach that will allow the results of the field work to be evaluated as each component is completed, thus guiding the progress and extent of subsequent field work components. As an example, with respect to investigation of LHSU groundwater in certain locations, monitoring wells will be installed and sampled in the uppermost LHSU sandstone unit as the first component of the groundwater field work. The samples will be submitted to the analytical laboratory for a quick turn-around analysis (24 hours) for a limited suite of indicator parameters (i.e., a reduced list of analytes selected for their utility and reliability as indicators of contamination), and the results will be evaluated as field work continues to determine whether deeper monitoring wells to lower LHSU permeable units are necessary. In this way, the investigation of LHSU groundwater can be expedited, while reducing the potential for needing additional later phases of field investigation.

It is anticipated that the Revised Bedrock Work Plan field investigation program activities can be completed in a period of approximately five months following mobilization to the field. This is in comparison to a duration of thirteen months required for the field program described previously in the Bedrock Work Plan (EG&G 1991e). Thus, by conducting a more focused LHSU investigation program and utilizing an observational approach, it will be possible to reduce the duration of field investigation program by eight months, thereby expediting completion of the Phase II RFI/RI for OU-2. A discussion of the anticipated schedule for the Revised Bedrock Work Plan field investigation program is presented in Section 4.0.

2.2 PROPOSED INVESTIGATION ACTIVITIES AND LOCATIONS

2.2.1 Proposed Investigation Activities

The Revised Bedrock Work Plan field investigation program involves the following general activities:

- Drilling of pilot boreholes at six well cluster locations (WC-1BH through WC-6BH) to evaluate LHSU bedrock stratigraphy and hydrogeologic conditions.

- Installation and development of two monitoring wells (WC-1a and WC-6a) to allow collection of groundwater quality samples from the uppermost LHSU sandstone unit beneath areas where contamination has been identified in the UHSU, and where the potential for hydraulic communication between the UHSU and LHSU is expected to be the greatest.

- Installation and development of one monitoring well (WC-5a) to allow collection of groundwater quality samples from the LHSU in an area where contamination has been detected previously in the LHSU.

- Installation and development of three monitoring wells (WC-2a, WC-3a, and WC-4a) to allow collection of groundwater quality samples from LHSU sandstone units that subcrop beneath the colluvium in the Woman Creek drainage and where contaminants have been detected previously.

- Collection of groundwater samples from wells WC-1a through WC-6a and analysis of the samples for a selected suite of indicator parameters to evaluate whether contaminants from the UHSU have migrated to LHSU bedrock units. For each particular location, if contaminants are detected in the LHSU unit being monitored, an additional monitoring well (e.g, WC-1b) will be installed into the next deeper permeable LHSU bedrock unit at that location. Groundwater samples will be collected from that well to evaluate the vertical extent of contamination in the LHSU.

- Conduct hydraulic slug tests within each newly-installed LHSU bedrock monitoring well to evaluate the permeability of LHSU bedrock units in which the monitoring wells have been installed.

- Drilling of two LHSU bedrock boreholes (SB-1 and SB-2) to collect samples of LHSU claystone for laboratory analysis to evaluate the vertical extent of contamination previously identified in the LHSU claystone at these locations.

- Examination of drill core from the borehole for existing Well 2087 to re-evaluate the lithology of the screened interval of this well.

In general, all field work will be conducted in accordance with existing RFP Standard Operating Procedures (SOPs). In some cases, however, modifications to the SOPs may be necessary to perform the field activities specified herein. Where procedures differ from those stated in the SOPs, they will be thoroughly documented in a document change notice (DCN). A list of existing SOPs applicable to the Revised Bedrock Work Plan field investigations is presented in Table 2-1.

2.2.2 Proposed Investigation Locations

The locations of the proposed boreholes and monitoring wells are shown on Figure 2-1. The rationale for each location and the activities to be performed are described below and are summarized in Table 2-2.

2.2.2.1 WC-1, WC-5, and WC-6

The purpose for monitoring wells at these locations is to investigate the potential for downward migration of contaminants from the UHSU to LHSU (scenario 2 type). For the purpose of this expedited field program, the investigation of potential downward migration of contaminants will focus in areas where UHSU contamination has been detected at the highest levels, and where the potential for hydraulic communication between the UHSU and LHSU is expected to be greatest (WC-1 and WC-6), or where contaminants have been previously detected (WC-5). Two locations (WC-1 and WC-6) were selected because they are within an UHSU contamination "hotspot" (Figure 1-26), and the uppermost LHSU sandstone is in close vertical proximity from the overlying No. 1 Sandstone (Figures 1-18 and 1-19). It is believed that these are among the most likely locations for LHSU contamination if it is occurring due to vertical migration from the UHSU to LHSU. If significant contamination is not detected in these locations, it is believed unlikely that it occurs elsewhere due to vertical migration from the UHSU to LHSU. The third location (WC-5) was selected because low levels of contamination have been identified in this area in an existing well completed in a LHSU claystone.

Figures 2-2 and 2-3 diagrammatically illustrate the approach to investigation at these three areas. Figure 2-2 addresses conditions expected for WC-1 and WC-6. Figure 2-3 addresses conditions expected for WC-5. Figure 2-4 presents a decision path diagram for locations WC-1, WC-5, and WC-6. The first step at each location will be to drill a pilot borehole through the uppermost three to four LHSU sandstone units to gather stratigraphic and hydrogeologic information. These data will be used to identify target depths for monitoring wells. The stratigraphic and hydrogeologic conditions at each location will be evaluated based on the results of lithologic and borehole geophysical logging. Following drilling and logging, the pilot borehole will be grouted to ground surface. Based on the data collected from the pilot borehole, an adjacent monitoring well (a-series well) will be installed into the uppermost LHSU sandstone unit (WC-1 and WC-6) or into the target interval (WC-5). If the uppermost sandstone units

TABLE 2-1
SUMMARY OF STANDARD OPERATING PROCEDURES
TO BE USED IN THE OU-2 REVISED
BEDROCK WORK PLAN FIELD INVESTIGATION PROGRAM

SOP NUMBER	TITLE
FO.1	Air Monitoring and Dust Control*
FO.2	Field Document Control
FO.3	General Equipment Decontamination
FO.4	Heavy Equipment Decontamination
FO.8	Handling of Drilling Fluids and Cuttings*
FO.10	Receiving, Labeling, and Handling Environmental Material Containers*
FO.13	Containerization, Preserving, Handling, and Shipping of Soil and Water Samples*
FO.14	Field Data Management
FO.15	Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs)
FO.16	Field Radiological Measurement
GT.1	Logging Alluvial and Bedrock Material
GT.2	Drilling and Sampling Using Hollow-Stem Auger Techniques*
GT.3	Isolating Bedrock From Alluvium With Grouted Surface Casing*
GT.4	Rotary Drilling and Rock Coring*
GT.5	Plugging and Abandonment of Boreholes*
GT.6	Monitoring Wells and Piezometers Installation*
GT.10	Borehole Clearing
GT.11	Plugging and Abandonment of Wells*
GT.15	Geophysical Borehole Logging*
GW.02	Well Development*
GW.04	Slug Testing*
GW.06	Well Sampling*

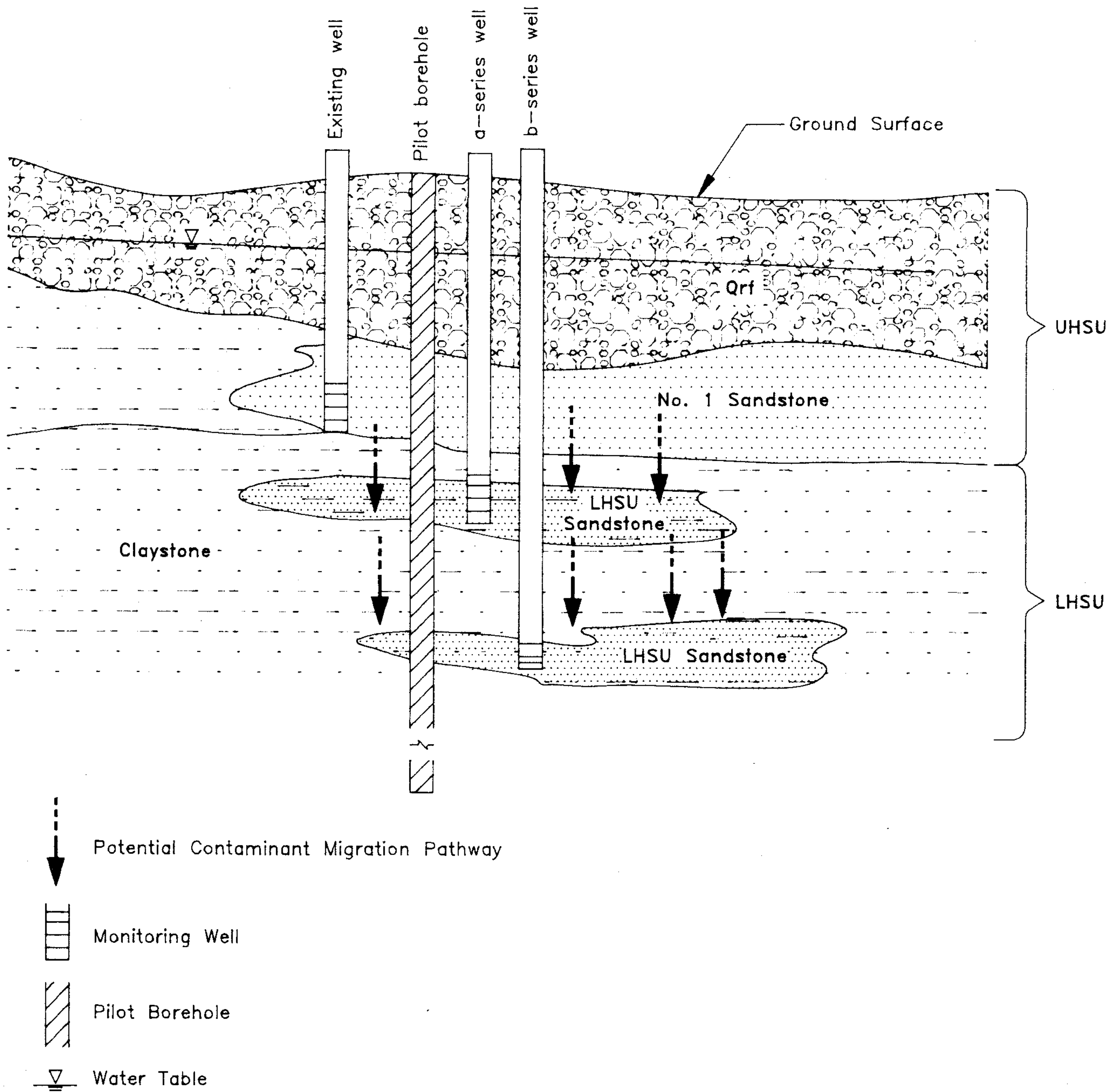
* May require modification for Revised Bedrock Work Plan field activities. Modifications, if necessary, will be documented with a DCN.

TABLE 2-2

SUMMARY OF RATIONALE FOR BOREHOLE/MONITORING WELL LOCATIONS AND OBJECTIVES/INFORMATION TO BE GAINED

Boring/Well Location	Rationale	Objective/Information
WC-1	Located in UHSU hotspot area with potential for hydraulic communication between UHSU and LHSU.	Investigate presence or absence of contamination in uppermost LHSU sandstone unit and next deeper sandstone unit, if necessary. Evaluate permeability of LHSU sandstones.
WC-2	Located upgradient of existing LHSU well screened near sandstone subcrop beneath colluvium.	Investigate source of contamination at existing well. Investigate presence or absence of contamination in deeper LHSU sandstone, if necessary. Evaluate permeability of LHSU sandstones.
WC-3	Located upgradient of existing LHSU well screened near sandstone subcrop beneath colluvium.	Investigate source of contamination at existing well. Investigate presence or absence of contamination in deeper LHSU sandstone, if necessary. Evaluate permeability of LHSU sandstones.
WC-4	Located upgradient of existing LHSU well screened near sandstone subcrop beneath colluvium.	Investigate source of contamination at existing well. Investigate presence or absence of contamination in deeper LHSU sandstone, if necessary. Evaluate permeability of LHSU sandstones.
WC-5	Located near existing LHSU well where contamination detected in LHSU below central portion of OU-2 plateau.	Confirm presence of contamination in LHSU. Evaluate type of LHSU material in screened interval of existing well. Investigate presence or absence of contamination in deeper LHSU sandstone, if necessary. Evaluate permeability of LHSU sandstones.
WC-6	Located in UHSU hotspot area with potential for hydraulic communication between UHSU and LHSU.	Investigate presence or absence of contamination in uppermost LHSU sandstone unit and next deeper sandstone unit, if necessary. Evaluate permeability of LHSU sandstones.
SB-1	Located adjacent to previous boring where contamination detected in LHSU claystone samples.	Investigate vertical extent of contamination in LHSU claystone.
SB-2	Located adjacent to previous boring where contamination detected in LHSU claystone samples.	Investigate vertical extent of contamination in LHSU claystone.
2087*	Existing LHSU well in 903 Pad Area where contamination has been detected below central portion of OU-2 plateau.	Re-evaluate lithology of screened interval as either a LHSU claystone or sandstone.

* Well 2087 is an existing well.



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

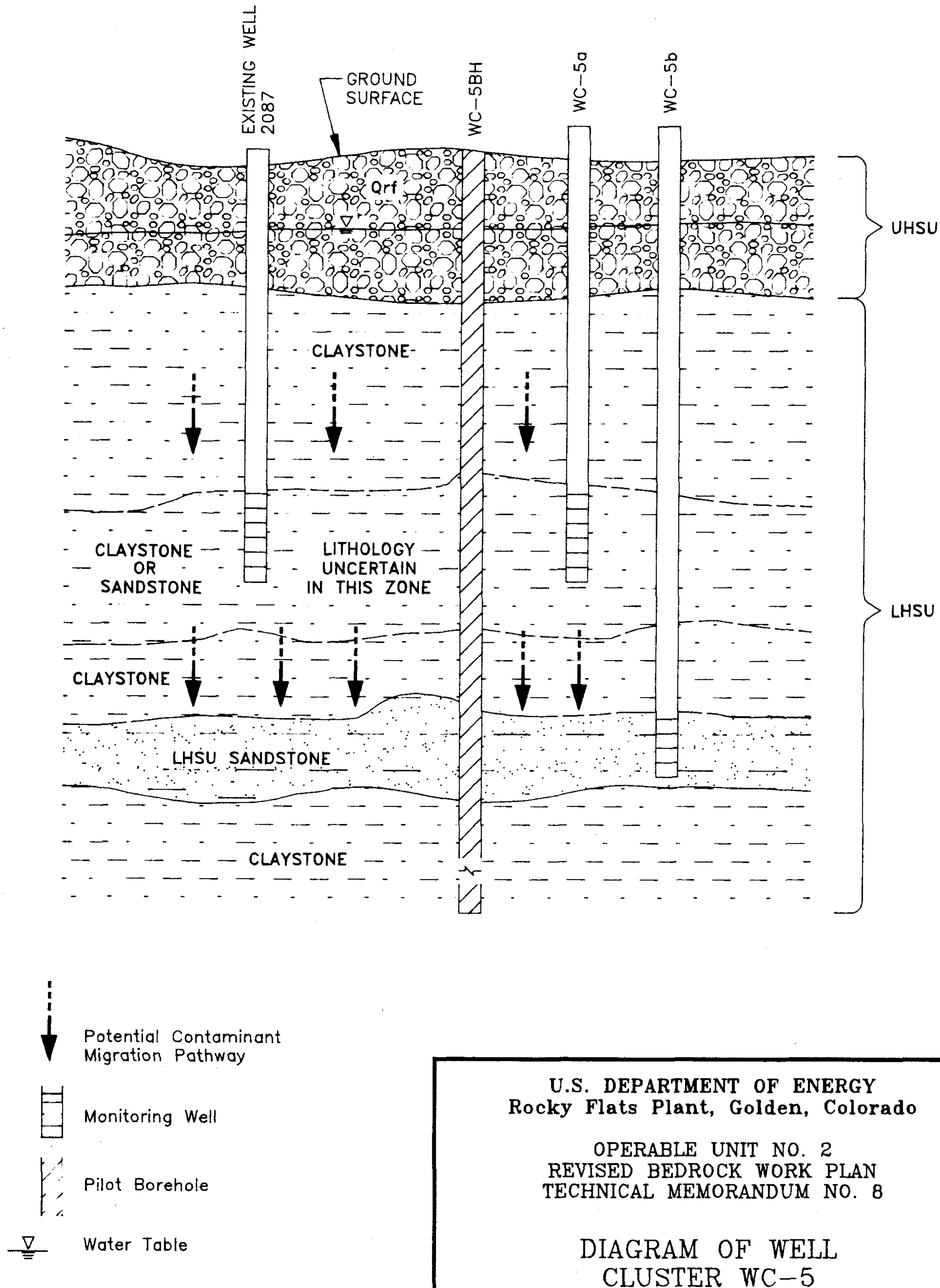
OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

TYPICAL LHSU WELL CLUSTER TO EVALUATE VERTICAL MIGRATION OF CONTAMINANTS FROM UHSU TO LHSU (SCENARIO 2)

FIGURE 2-2

MARCH 1993

3047E01



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DIAGRAM OF WELL
CLUSTER WC-5

FIGURE 2-3

MARCH 1993

3047E07

at locations WC-1 and WC-6 do not have sufficient thickness to warrant installation of a well, the a-series well will be installed in the next deeper LHSU sandstone. Following installation, the a-series well will be developed. It is estimated that development of LHSU wells will require up to 4 weeks due to low water yield from the wells. If development requires more than 4 weeks, it will be concluded that the permeability of the a-series well LHSU unit is too low to allow it to act as a LHSU exposure pathway at that location and field work will be discontinued at that location. Wells that cannot be developed within 4 weeks will be monitored under the RFP site-wide groundwater monitoring program. If the well can be developed within 4 weeks, it will be sampled for groundwater quality and the samples submitted to the analytical laboratory for analysis for indicator parameters on a quick turn-around basis (see Section 2.7.4.1). Based on the analytical results, a determination will be made as to whether contamination is present in the a-series target unit. If contamination is present, a second well (b-series well) will be installed adjacent to the a-series well into the next deeper LHSU sandstone unit and sampled to evaluate the vertical extent of the contamination in the LHSU at that location. The following paragraphs discuss each location in detail.

WC-1 High concentrations of organic contaminants (up to 96,000 ppb of TCE) have been detected in the No. 1 Sandstone in existing Well 3687 near this location (Figures 1-18 and 1-26). One monitoring well (WC-1a) will be installed adjacent to and downgradient of Well 3687 to evaluate whether contaminants have migrated vertically from the No. 1 Sandstone at this location to the uppermost LHSU sandstone. Based on the lithologic information for Well 3687, it appears that the uppermost LHSU sandstone at that location may be very thin and silty (Figure 1-18). During drilling of Well 3687, only about 2 to 5 feet of sandstone was encountered before the borehole reentered claystone. Information collected during drilling and logging of the pilot borehole at this location (WC-1BH) will be used to evaluate the thickness and quality of the uppermost LHSU sandstone at this location and evaluate its vertical proximity to the UHSU. Based on the information from the pilot boring, a monitoring well will be installed into the uppermost LHSU sandstone (if sufficient sandstone thickness is present) to allow collection of groundwater samples from that unit. If the analytical results from those samples indicate that contamination is present in the uppermost LHSU sandstone, a second deeper well (WC-1b) will be installed in the next deeper LHSU permeable unit (estimated to occur at an elevation of 5850 ft) to evaluate whether contamination has migrated vertically to that unit.

WC-5 Well WC-5a will be installed near Well 2087, which has exhibited low levels of organic contaminants (39 ppb or less of PCE) in groundwater samples from that well (Figures 1-16 and 1-29). Well 2087 is in the vicinity of IHSS No. 113. The geologic and well construction logs from Well 2087 indicate that the well is screened in a silty claystone bedrock. However, recent mapping of LHSU sandstones indicates that a sandstone unit may be present at the screened interval of Well 2087. To resolve this uncertainty, the core samples for the screened interval of Well 2087 will be relogged. In addition, well WC-5a will be installed upgradient of Well 2087 to confirm the presence of contamination in the LHSU in the screened interval of Well 2087. If the analytical results for samples from WC-5a indicate contamination is present, a second deeper monitoring well (WC-5b) will be installed in the next deeper permeable LHSU unit (approximate depth of 5840 feet) to evaluate whether contamination has migrated vertically to that unit.

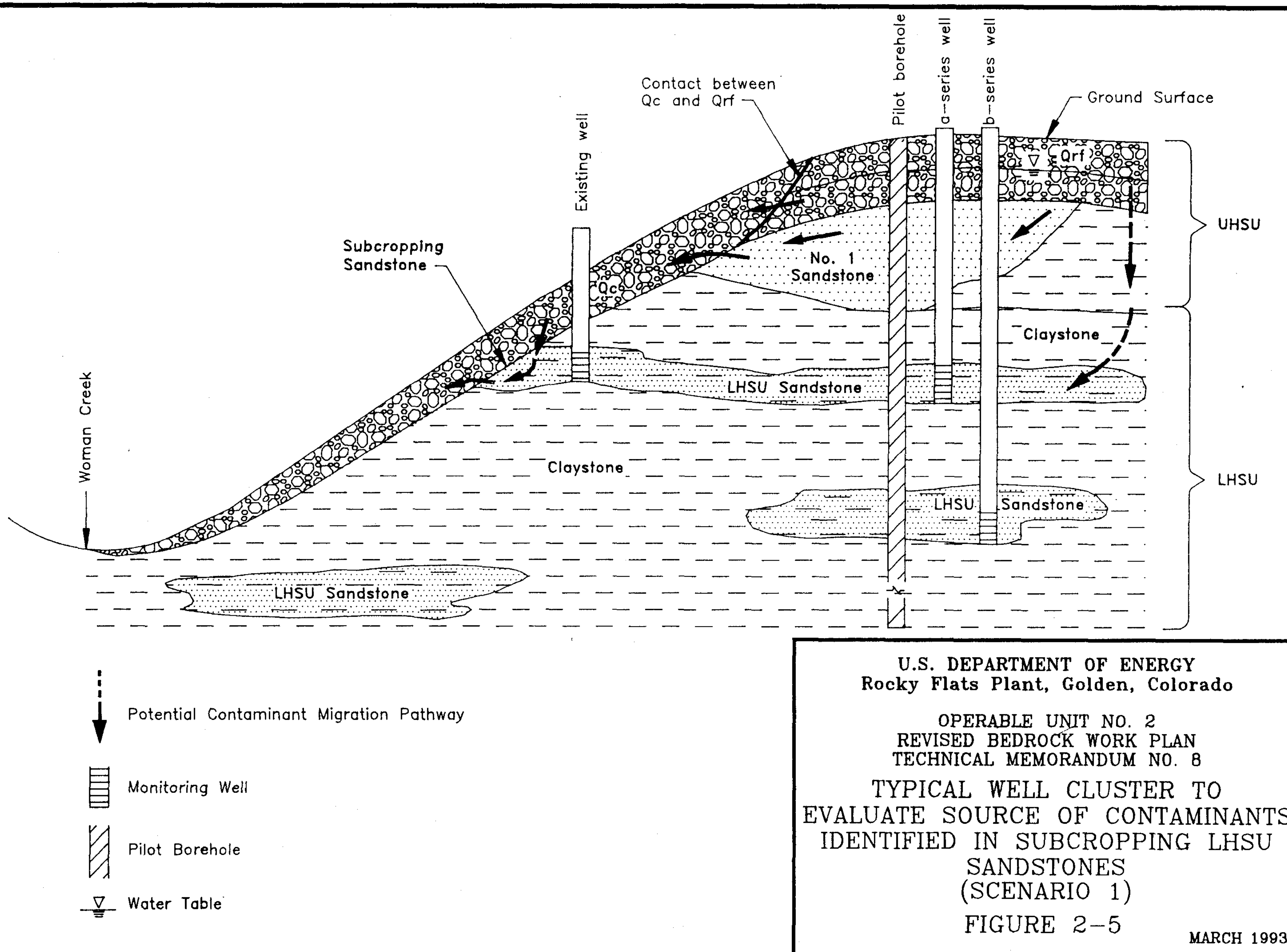
WC-6 Well WC-6a will be installed near existing Well 02991, which is completed in the No. 1 Sandstone and in which organic contaminants have been detected (up to 560 ppb of CCl_4) (Figure 1-26). The purpose of this well cluster is to allow monitoring of the uppermost LHSU sandstone beneath the alluvial hotspot (Figure 1-26) where the LHSU sandstone is in close vertical proximity to the UHSU. If the analytical results for samples from WC-6a indicate contamination is present in the uppermost LHSU sandstone, a second deeper monitoring well (WC-6b) will be installed in the next deeper permeable LHSU unit to evaluate whether contamination has migrated vertically to that unit.

2.2.2.2 WC-2, WC-3, and WC-4

Wells WC-2, WC-3, and WC-4 will be installed into LHSU sandstone units upgradient from where contaminants have been detected in those units where they subcrop beneath the colluvium along the Woman Creek drainage (scenario 1 type). The purpose of the wells will be to evaluate whether the contaminants identified in the LHSU sandstone units are the result of localized recharge of contaminated colluvial water to the sandstone subcrops, or are the result of downward vertical migration from the UHSU source areas and subsequent lateral migration within the sandstones to the subcrop areas. The new wells will be installed upgradient and away from the subcrop areas so as to be outside the influence of localized recharge of colluvial water to the LHSU sandstones, if it is occurring.

Figure 2-5 diagrammatically illustrates the approach to investigation at these three areas. Figure 2-6 presents a decision path diagram for locations WC-2, WC-3 and WC-4. Again, the first step at each location will be to drill a pilot borehole through the LHSU sandstone of interest and the next deeper two to three LHSU sandstone units to gather stratigraphic and hydrogeologic information. These data will be used to identify target depths for monitoring wells. Based on the data collected from the pilot borehole, an adjacent monitoring well (a-series

3047E02



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

TYPICAL WELL CLUSTER TO EVALUATE SOURCE OF CONTAMINANTS IDENTIFIED IN SUBCROPPING LHSU SANDSTONES (SCENARIO 1)

FIGURE 2-5

MARCH 1993

well) will be installed into the LHSU sandstone unit in which contamination was previously detected. Following installation, that well will be developed. If development requires more than 4 weeks, it will be concluded that the permeability of the a-series well LHSU unit is too low to allow it to act as a LHSU exposure pathway at that location and field work will be discontinued at that location. Wells that cannot be developed within 4 weeks will be monitored under the RFP site-wide groundwater monitoring program. If the well can be developed within 4 weeks, it will be sampled for groundwater quality and the samples submitted to the analytical laboratory for analysis for indicator parameters on a quick turn-around basis. Based on the analytical results, an assessment will be made as to whether contamination is present in that LHSU sandstone unit at the new well location. If contamination is not present in the new well, it will be concluded that the contaminants detected in the existing well near the subcrop were introduced to the LHSU sandstone through localized contaminated colluvial water migration into the sandstone and, as such, are associated with an UHSU exposure pathway. If contamination is detected in the new well, it will be an indication that the contamination migrated vertically to the LHSU sandstone from an UHSU secondary source area and then migrated laterally within the LHSU sandstone to the subcrop location. In that case, a second well (b-series well) will be installed adjacent to the a-series well into the next deeper LHSU sandstone unit and sampled to evaluate the vertical extent of the contamination in the LHSU at that location. The following paragraphs discuss each location in detail.

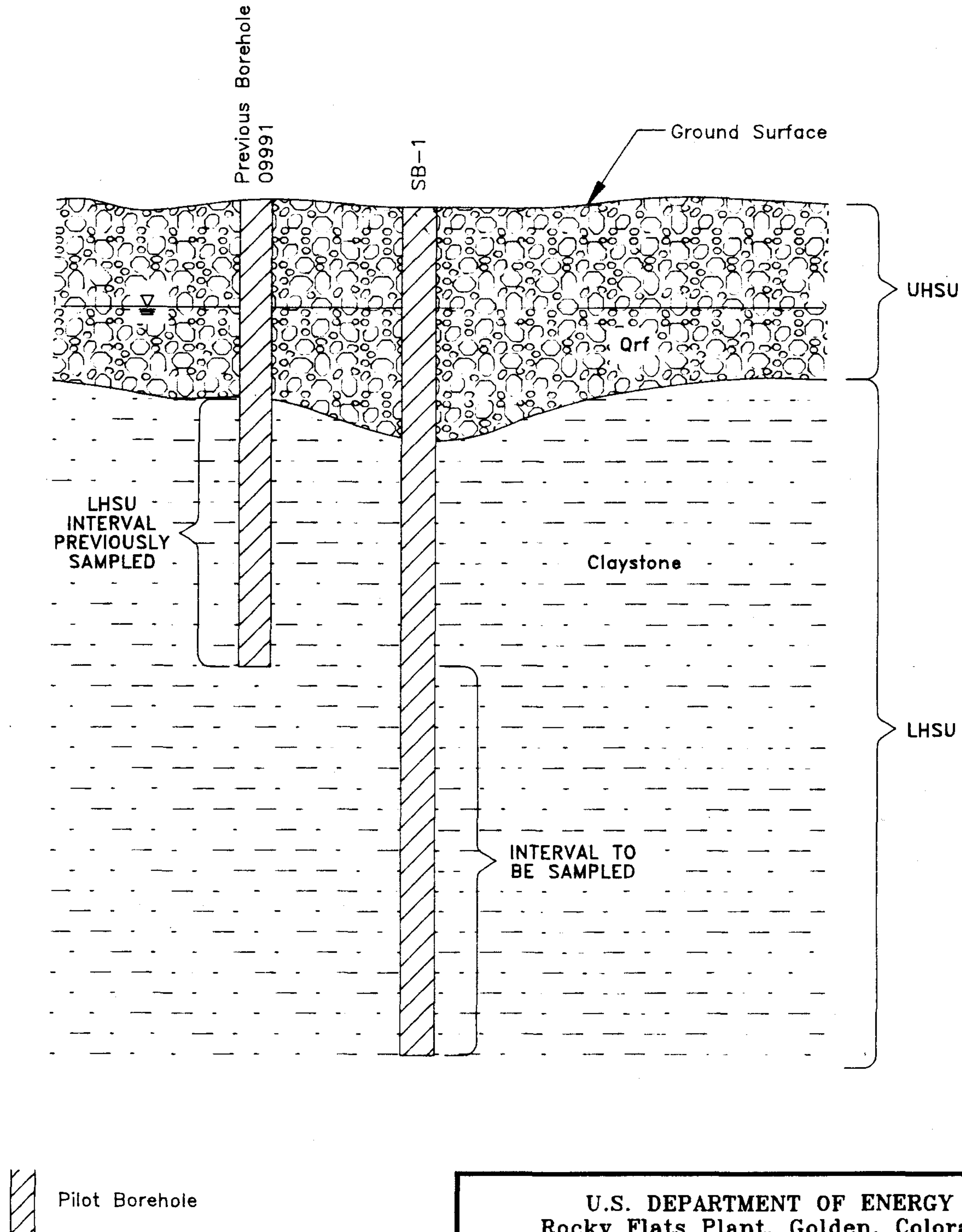
<u>WC-2</u> High concentrations of organic contaminants (up to 3,300 ppb of TCE) have been identified in groundwater samples from Well 1187, which is completed in the uppermost LHSU sandstone where it subcrops beneath the colluvium on the north slope of the Woman Creek drainage (Figures 1-16 and 1-25). Investigation activities will be conducted at location WC-2 (Figure 2-1) to evaluate whether the identified contamination observed in Well 1187 is migrating into the LHSU sandstone from localized recharge of contaminated colluvial water, or is migrating vertically into the sandstone from an UHSU secondary source and then laterally within the sandstone to Well 1187. The well will be installed upgradient and sufficiently distant from Well 1187 to minimize the potential for influences from local recharge of colluvial water to the sandstone, if it is occurring. If contamination is not identified in samples from WC-2a, it will be concluded that the contamination identified in Well 1187 is originating from local recharge of colluvial water to the LHSU sandstone where it subcrops. If contamination is identified in samples from WC-2a, it will be concluded that the contamination is migrating to the sandstone vertically from an UHSU secondary source and then laterally within the sandstone to the location of Well 1187. If contamination is identified in samples from WC-2a, a second well, WC-2b will be installed to the next deeper permeable LHSU unit to evaluate whether contamination has migrated vertically to that unit.

Similar procedures will be conducted for wells WC-3a and WC-4a as are proposed for Well WC-2a. WC-3a and WC-4a will be installed to evaluate the source of contamination identified in samples from Wells 00391 (up to 890 ppb of CCl_4) and 1487 (up to 460 ppb of CCl_4), respectively (Figure 1-25). Wells 00391 and 1487 are screened in LHSU sandstones near where they subcrop along the Woman Creek valley. It is uncertain whether the contamination identified in samples from Wells 00391 and 1487 is due to localized recharge of contaminated colluvial water, or is related to lateral migration of contaminants within the sandstones. WC-3a and WC-4a will be installed upgradient of Wells 00391 and 1487, respectively, to aid in resolving this uncertainty. If contamination is identified in samples from WC-3a of WC-4a, deeper wells (WC-3b and WC-4b) will be installed to the next deeper permeable LHSU units to evaluate whether contamination has migrated vertically to those units.

2.2.2.3 SB-1 and SB-2

Two boreholes, SB-1 and SB-2, will be drilled adjacent to existing Boreholes 09991 and BH2587, respectively, to evaluate the vertical extent of contamination identified in LHSU claystone bedrock samples previously collected in those areas. The two existing boreholes (09991 and BH2587) were drilled to depths of 20 and 22.5 feet below ground surface, respectively. Samples of claystone bedrock collected from the bottom of those boreholes contained volatile organic compounds (Figures 1-30 and 1-31). SB-1 and SB-2 will be drilled to collect samples of claystone bedrock below the depths previously collected to evaluate the vertical extent of the identified contamination. Figure 2-7 diagrammatically illustrates the approach to be used for SB-1 and SB-2. A discussion of each location is provided below.

<u>SB-1</u> SB-1 will be drilled within 10 feet of Borehole 09991 (within IHSS No. 113), which was drilled previously to a depth of 20 feet. Analysis of the deepest claystone bedrock sample collected from Borehole 09991 indicated that PCE was present at a concentration of 180 ppb. SB-1 will extend to a depth of about 50 feet to allow collection of claystone bedrock samples from the 20 to 50 foot depth interval to aid in evaluating the vertical extent of contaminants in the LHSU claystone in this area.



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

TYPICAL BOREHOLE

FIGURE 2-7

MARCH 1993

3047E05

SB-2 SB-2 will be drilled within 10 feet of Borehole BH2587 (within IHSS No. 109), which was previously drilled to a depth of 22.5 feet. Analysis of claystone bedrock samples collected from Borehole BH2587 indicated that TCE and PCE were present at concentrations of 13,000 ppb and 2,100 ppb, respectively, in the deepest sample from this borehole. SB-2 will extend to a depth of about 50 feet to allow collection of claystone bedrock samples from the 22.5 to 50 foot depth interval to aid in evaluating the vertical extent of contaminants in the LHSU claystone in this area.

2.2.2.4 Existing Well 2087

Well 2087 As discussed in Section 1.2.1.2, Well 2087 (903 Pad Area) has exhibited low levels of organic contaminants usually near the detection limit for PCE and TCE with a one-time 39 ppb detection of PCE. This well is reportedly screened in LHSU claystone, but recent mapping indicates that a LHSU sandstone may be present at the screened interval of Well 2087. The core samples for the screened interval of Well 2087 will be re-examined to resolve whether the lithology of the screened interval is LHSU claystone or sandstone. Logging of the core will be in accordance with SOP GT.1, Logging Alluvial and Bedrock Material.

2.3 DRILLING AND SOIL SAMPLING METHODS

This section describes the nature and sequence of field methods to be implemented with regard to drilling, coring, geophysical logging, and soil/rock sampling. Subsection 2.3.1 discusses field methods to be implemented at borehole locations SB-1 and SB-2, and Section 2.3.2 discusses procedures to be implemented at pilot borehole and monitoring well locations. The drilling methods discussed in the following sections are the preferred drilling methods for the Revised Bedrock Work Plan field program. However, alternative drilling methods may be employed if site conditions warrant such action. Figure 2-1 shows the Revised Bedrock Work Plan LHSU borehole locations, and the LHSU bedrock pilot borehole and monitoring well locations. Prior to drilling, the locations for all boreholes, pilot boreholes, and wells will be geophysically cleared in accordance with SOP GT.10, Borehole Clearing and radiologically surveyed in accordance with SOP FO.16, Field Radiological Measurements.

2.3.1 Boreholes SB-1 and SB-2

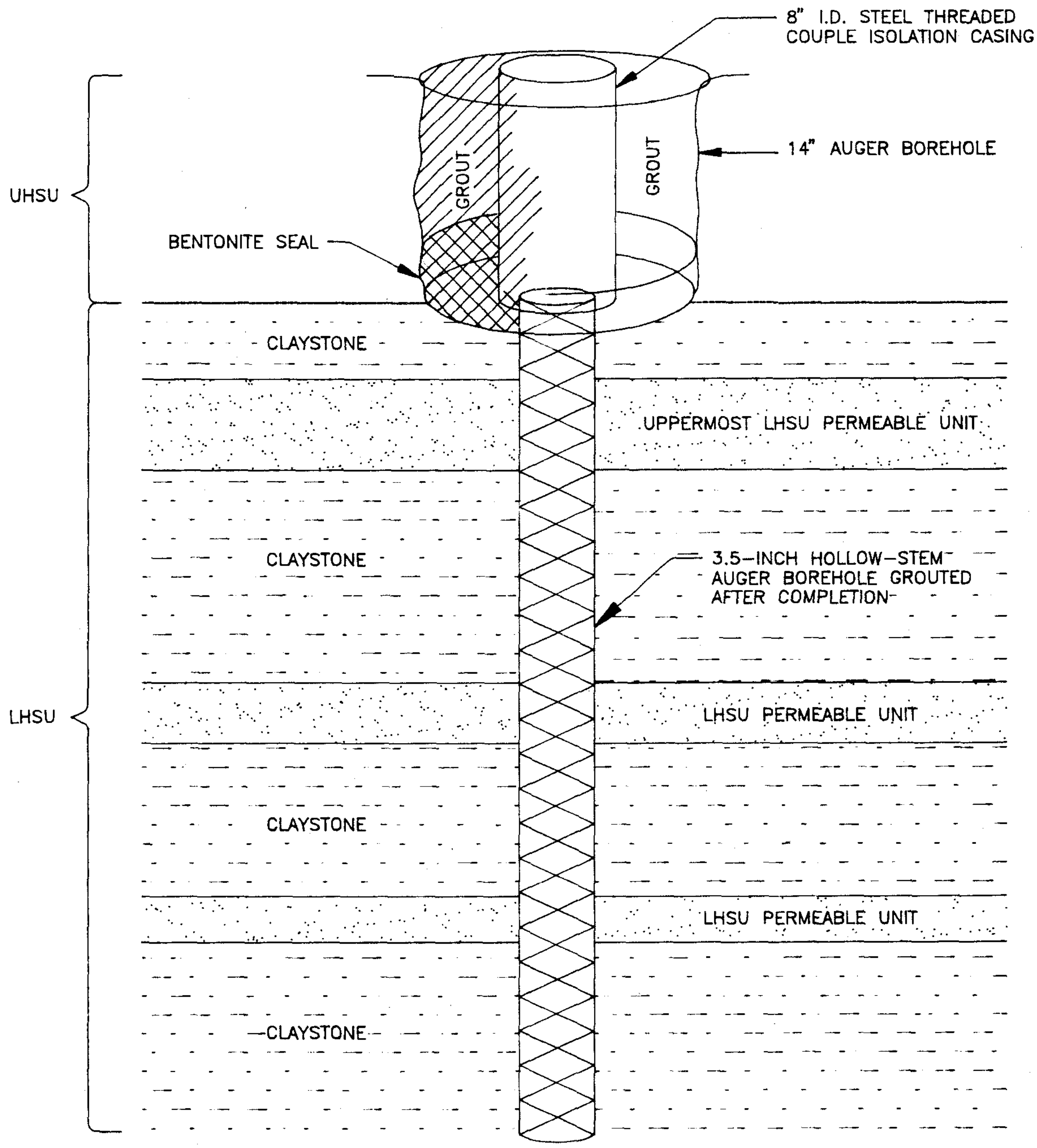
Two boreholes, SB-1 and SB-2, will be drilled to evaluate the vertical extent of contamination identified in LHSU claystone bedrock samples previously collected in those areas. The following paragraphs discuss the drilling and soil/rock sampling procedures to be implemented for the two boreholes. Figure 2-8 shows a diagram of a typical borehole.

2.3.1.1 Auger Drilling to Install Isolation Casing for Boreholes SB-1 and SB-2

The initial drilling conducted at each location will consist of installing an isolation casing across the UHSU prior to drilling into the underlying LHSU bedrock. This casing will isolate the bedrock borehole (to be drilled later) from the UHSU. This drilling activity will be performed using hollow-stem auger drilling methods. However, if refusal is met using the hollow-stem auger drilling method, then alternative drilling methods capable of performing this drilling activity will be employed. The following discussion assumes using the hollow-stem auger drilling method.

Drilling will initially proceed through the UHSU with 3.5-inch internal diameter (I.D.) hollow-stem augers. As drilling progresses through the UHSU, continuous core samples will be collected over 2-foot intervals. If LHSU claystone is present immediately beneath the UHSU, the auger holes will continue 3 feet into the claystone. As drilling into the claystone over this three foot interval progresses, continuous core samples will be collected over one foot intervals to verify that 3 feet of claystone is present. If the core samples indicate that 3 feet of claystone is not present immediately beneath the UHSU, the auger holes will be terminated at the point at which LHSU siltstone or sandstone is encountered. If siltstone or sandstone is present immediately beneath the UHSU, the auger holes will terminate at the base of the UHSU (i.e., at the base of the Rocky Flats Alluvium or the No. 1 Sandstone). Following completion of drilling with the 3.5-inch I.D. augers, the borehole will be reamed to a diameter of about 12 inches or greater using hollow-stem augers. Hollow-stem drilling and sampling will be performed in accordance with SOP GT.2, Drilling and Sampling Using Hollow-stem Auger Techniques.

Following drilling and reaming, an 8-inch I.D. steel isolation casing with water tight threaded couplings will be installed to isolate the borehole from the UHSU. Following installation of the isolation casing in a borehole, a 3-foot thick bentonite seal consisting of 1/4-inch compressed bentonite pellets will be placed at the bottom of the annulus surrounding the isolation casing to prevent the isolation casing grout seal from intruding into the underlying LHSU unit (Figure 2-8). Following installation of the bentonite seal, the remaining portion of the borehole annulus surrounding the isolation casing will be grouted from the top of the bentonite seal to ground surface to seal the isolation casing in place. Installation and sealing of isolation casings will be in accordance with SOP GT.3, Isolating Bedrock from Alluvium with Grouted Surface



NOT TO SCALE

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DIAGRAM OF DETAILS OF TYPICAL BOREHOLE

FIGURE 2-8

MARCH 1993

3047E06

Casing. It is estimated that the isolation casing will extend to depths of about 16 and 18 feet below ground surface for SB-1 and SB-2, respectively. The grout used to seal the isolation casing will be allowed to cure for a minimum of 24 hours prior to initiating drilling of the source borehole into LHSU bedrock at the location. Table 2-3 summarizes borehole depths and indicates the estimated depth of each isolation casing.

2.3.1.2 Hollow-Stem Auger Drilling in LHSU Bedrock

Following curing of the isolation casing grout seal, hollow-stem auger drilling will be performed within the isolation casing to extend the borehole into the LHSU bedrock underlying the UHSU. Hollow-stem drilling is proposed because it will minimize the potential for impacts to the quality of analytical samples to be collected. It is anticipated that the boreholes can be advanced to the target depths without encountering refusal using hollow-stem auger drilling techniques. If refusal is encountered, an alternate drilling method may be required.

Drilling will proceed to approximate depths of 50 feet below ground surface. As drilling progresses, claystone bedrock samples will be collected on a continuous basis using a modified split-spoon sampler. Discrete samples for VOC analysis will be collected every 4 feet. Samples for analysis for other parameters will be composited over six foot intervals. Analysis of subsurface bedrock samples are discussed in Section 2.7.1. Hollow-stem auger sampling will be performed in accordance with SOP GT.2, Drilling and Sampling using Hollow-Stem Auger Techniques. All split spoon samples obtained from each borehole will be lithologically logged in accordance with SOP GT.1, Logging Alluvial and Bedrock Material.

Following drilling and sampling of the source boreholes, the boreholes will be plugged and abandoned in accordance with GT.5, Plugging and Abandonment of Boreholes. The steel isolation casing used in the source boreholes must be removed during plugging and abandonment as required by GT.11, Plugging and Abandonment of Wells. To prevent an inflow of UHSU water into the LHSU bedrock borehole when the isolation casing is removed, the portion of the borehole penetrating LHSU bedrock will be grouted prior to removal of the isolation casing. The isolation casing will then be removed by pulling or over drilling, and the remainder of the borehole will be grouted to ground surface to complete the plugging and abandonment.

TABLE 2-3
SUMMARY OF PROPOSED BORINGS AND WELLS

Boring/ Well No.	Total Boring Depth* (ft below g.s.)[1]	Approximate** Isolation Casing Depth (ft below g.s.)	Approximate Depth of Screened Interval*** (ft below g.s.)	Type of Well Casing	Perforation Type
WC-1BH	160	65	NA[2]	NA	NA
-1a	77	65	66-72	2" I.D. Sch. 80 PVC	0.01 inch slotted
-1b	115	65, 75	100-110	2" I.D. Sch. 80 PVC	0.01 inch slotted
WC-2BH	140	17	NA	NA	NA
-2a	52	17	37-47	2" I.D. Sch. 80 PVC	0.01 inch slotted
-2b	115	17, 50	100-110	2" I.D. Sch. 80 PVC	0.01 inch slotted
WC-3BH	200	50	NA	NA	NA
-3a	70	50	55-65	2" I.D. Sch. 80 PVC	0.01 inch slotted
-3b	115	50, 68	85-95	2" I.D. Sch. 80 PVC	0.01 inch slotted
WC-4BH	130	18	NA	NA	NA
-4a	70	18	55-65	2" I.D. Sch. 80 PVC	0.01 inch slotted
-4b	100	18, 68	75-85	2" I.D. Sch. 80 PVC	0.01 inch slotted
WC-5BH	175	18	NA	NA	NA
-5a	130	18	110-120	2" I.D. Sch. 80 PVC	0.01 inch slotted

TABLE 2-3
(Concluded)

Boring/ Well No.	Total Boring Depth* (ft below g.s.)[1]	Approximate** Isolation Casing Depth (ft below g.s.)	Approximate Depth of Screened Interval*** (ft below g.s.)	Type of Well Casing	Perforation Type
-5b	145	18, 130	130-140	2" I.D. Sch. 80 PVC	0.01 inch slotted
WC-6BH	150	53	NA	NA	NA
-6a	70	53	55-65	2" I.D. Sch. 80 PVC	0.01 inch slotted
-6b	117	53, 68	102-112	2" I.D. Sch. 80 PVC	0.01 inch slotted
SB-1	50	16	NA	NA	NA
SB-2	50	18	NA	NA	NA

* If a sandstone or siltstone is encountered at proposed total depth, continue drilling until 5 feet of underlying claystone has been penetrated.
** Isolation casing will be installed 3 feet into LHSU claystone or at the base of the UHSU if a LHSU siltstone or sandstone is present immediately beneath the UHSU. If two depths shown, they are for UHSU isolation casing and a-series interval isolation casing, respectively.
*** Screen length may be shortened if insufficient sandstone thickness is present in target screened interval.
1 g.s. = ground surface
2 Not applicable.

2.3.2 Pilot Boreholes and Monitoring Wells

The following discussion describes the sequence of field activities to be conducted at each bedrock pilot borehole and monitoring well drilling location. Figure 2-1 shows the six LHSU bedrock pilot borehole and monitoring well locations (WC-1 through WC-6). Figure 2-9 is a diagram showing the borehole and well construction features for a typical borehole/well cluster.

2.3.2.1 Installation of Isolation Casings in Pilot Boreholes and Monitoring Well Boreholes

As for boreholes SB-1 and SB-2, the initial drilling at each pilot borehole and monitoring well location will consist of installing an isolation casing across the UHSU prior to drilling into the underlying bedrock. This casing will isolate the bedrock borehole (to be drilled later) from the UHSU (Figure 2-9). This drilling activity will be performed using hollow-stem auger drilling methods. However, if refusal is met using the hollow-stem auger drilling method, then alternative drilling methods capable of performing this drilling activity will be employed. The following discussion assumes using the hollow-stem auger drilling method.

Drilling will initially proceed through the UHSU with 3.5-inch I.D. hollow-stem augers. As drilling progresses through the UHSU, continuous core samples will be collected over two foot intervals. If claystone is present immediately beneath the UHSU, the auger holes will continue 3 feet into the claystone. As drilling into the claystone over this three foot interval progresses, continuous core samples will be collected over one foot intervals to verify that 3 feet of claystone is present. If the core samples indicate that 3 feet of claystone is not present immediately beneath the UHSU, the auger holes will be terminated at the point at which LHSU siltstone or sandstone is encountered. If siltstone or sandstone is present immediately beneath the UHSU, the auger holes will terminate at the base of the UHSU (i.e., the base of the Rocky Flats Alluvium or the No. 1 Sandstone). Following completion of drilling with the 3.5-inch I.D. augers, the borehole will be reamed to a diameter of about 10 inches (pilot boreholes), 12 inches (a-series well boreholes) or 14 inches (b-series well boreholes) using hollow-stem augers. Hollow-stem drilling and sampling will be performed in accordance with SOP GT.2, Drilling and Sampling Using Hollow-stem Auger Techniques.

Following drilling and reaming, isolation casing will be installed in the boreholes to isolate the boreholes from the UHSU. For the pilot boreholes, a 6-inch I.D. PVC flush-jointed isolation casing will be used. For a-series monitoring wells, an 8-inch I.D. steel isolation casing will be installed. For the b-series wells, a 10-inch steel isolation casing will be installed. The b-series wells require a larger isolation casing than the a-series wells because they must allow for installation of a second isolation casing across the LHSU unit to be screened by the a-series well (Figure 2-9). The isolation casings will have water tight threaded couplings and will extend from ground surface to the bottom of the borehole. Following installation of the isolation casing in a borehole, a 3-foot-thick bentonite seal consisting of 1/4-inch compressed bentonite pellets will be placed at the bottom of the borehole annulus surrounding the isolation casing to prevent the isolation casing grout seal from intruding into the underlying LHSU unit (Figure 2-9). Following placement of the bentonite seal, the remaining portion of the borehole annulus surrounding the isolation casing will be grouted from the top of the bentonite seal to ground surface to seal the isolation casing in place. Installation and sealing of the isolation casings will be in accordance with SOP GT.3, Isolating Bedrock from Alluvium with Grouted Surface Casing. The grout used to seal the isolation casings will be allowed to cure for a minimum of 24 hours prior to initiating drilling of the borehole into bedrock at the location. Table 2-3 summarizes borehole and well depth information and indicates the estimated depth of each isolation casing.

2.3.2.2 Pilot Boreholes

Following curing of the isolation casing grout seal, rotary core drilling will be performed within the isolation casing to extend the borehole into the LHSU bedrock underlying the UHSU. The purpose of this drilling activity will be to gather information on the stratigraphic and hydrogeologic conditions within the LHSU bedrock at each location which will be used in selecting target screen intervals for the monitoring well(s). This drilling activity will be performed with a rotary drill rig equipped for continuous core drilling (HX size).

Drilling in the pilot borehole will proceed through the first three to four LHSU sandstone units at each location. The estimated depths for each pilot borehole are summarized on Table 2-3. Drilling will be conducted using REVERT drilling mud as the drilling fluid. The use of drilling mud will result in a higher hydraulic head within the borehole than in the surrounding bedrock, thereby inducing a hydraulic gradient away from the borehole to the surrounding bedrock and preventing inflow of groundwater as the borehole passes through LHSU permeable zones. In this way, the potential for cross-contamination between permeable zones in the LHSU bedrock through the borehole will be minimized. As drilling progresses, continuous core samples (HX size) will be collected with a core barrel. Core runs will not exceed 5 feet in length. Rotary drilling and coring will be performed in accordance with SOP GT.4, Rotary Drilling and Rock Coring. All drill core collected from the pilot borehole will be lithologically logged in accordance with SOP GT.1, Logging Alluvial and Bedrock Material. Because the well borings at a particular location will be drilled adjacent to the pilot borehole, they will not be logged.

Core samples removed from the boring will be immediately screened in the field for VOCs using an organic vapor analyzer (OVA). Operation and maintenance of OVAs will be in accordance with SOP FO.15, Photoionization Detectors (PIDs) and Flame Ionization Detectors (FIDs). In addition to the VOC screening, the core samples will be field screened for radiological contaminants in accordance with SOP FO.16, Field Radiological Measurements. Samples for characterization of drill cuttings are discussed in Section 2.7.2. Core samples submitted for laboratory analysis will be handled in accordance with SOP FO.13, Containerization, Preserving, Handling, and Shipping of Soil and Water Samples.

In addition to the core samples collected for analytical laboratory testing, geotechnical samples will be collected to evaluate the permeability and physical properties of the LHSU bedrock materials. Geotechnical samples will be collected from each LHSU lithologic unit (i.e., each sandstone, siltstone, and claystone interval) encountered within the borehole and will be tested in the geotechnical laboratory for vertical and horizontal permeability, porosity, moisture content, bulk density, and grain size distribution.

Following completion of drilling and coring, downhole geophysical logging will be performed in the pilot borehole to provide information on geologic and hydrogeologic conditions within the LHSU bedrock surrounding the borehole. The following geophysical logs will be performed within the borehole:

- temperature
- fluid resistivity
- spontaneous potential
- resistivity, 16-inch and 64-inch
- induction
- gamma density
- neutron
- natural gamma
- sonic (full wave form)
- caliper
- acoustic televiewer

The geophysical logging will be conducted while the borehole contains the drilling mud. Geophysical logging will be performed in accordance with SOP GT.15, Geophysical Borehole Logging. Following geophysical logging, the borehole will be plugged and abandoned in accordance with SOP GT.5, Plugging and Abandonment of Boreholes. Because the isolation casing used for the pilot boreholes will be PVC, it will not have to be removed during plugging and abandonment.

2.3.2.3 Monitoring Wells

Based on drilling observations and the results of the geophysical logging in the pilot borehole, the LHSU sandstone units of interest will be identified for placement of the a-series and b-series monitoring wells. For locations WC-1, WC-5, and WC-6, the a-series wells unit of interest is expected to be the uppermost sandstone unit in the LHSU bedrock, but may alternatively be a permeable fractured claystone interval if such an interval is present in the LHSU above the first bedrock sandstone unit. For locations WC-2, WC-3, and WC-4, the a-series wells wills be installed in the sandstone units in which contaminants have been detected where the sandstone subcrops beneath the colluvium.

The a-series well will be drilled about 15 feet away from the pilot borehole at each location. Drilling will be performed using air rotary drilling techniques. The well borehole will be advanced within the isolation casing using air rotary drilling methods with a 5 7/8-inch outside diameter (O.D.) tricone bit and will be terminated at a depth of about 5 feet below the bottom of the interval to be screened. Air rotary drilling methods will be used to avoid problems associated with drilling mud which can sometimes impact the permeability of the borehole walls and the quality of water samples, and to reduce the amount of waste generated from drilling fluids.

For the b-series wells, the borehole will be advanced using air rotary methods from the top of the LHSU through the LHSU unit being monitored by the a-series well to an elevation a few feet below that unit. The borehole will then be reamed to a diameter of 9 5/8-inch to allow installation of a second isolation casing across the unit being monitored by the a-series well (Figure 2-9). A second casing is necessary to ensure that cross-contamination does not occur through the borehole between the a-series well LHSU unit and the b-series well LHSU unit. Following reaming, a 6-inch I.D. steel isolation casing with water-tight joints will be installed in the borehole to seal off the a-series well LHSU unit from the borehole. Installation of the isolation casing will be performed in a similar manner as was used for the UHSU isolation casing, and will be in accordance with SOP GT.3, Isolating Bedrock from Alluvium with Grouted Surface Casing except as modified as necessary for this purpose. Following installation of the isolation casing, and allowing 24 hours for the grout seal to cure, the borehole will then be advanced using air rotary drilling methods with a 5 7/8-inch tricone bit and will be terminated at a depth of about 5 feet below the bottom of the interval to be screened.

Following drilling of the well borehole, a monitoring well will be installed within the borehole to allow collection of groundwater samples from the LHSU unit of interest (Figure 2-9). The monitoring well will be constructed of 2-inch I.D. Schedule 80 flush-jointed PVC monitoring pipe and machine-slotted well screen. The monitoring well will have a 10-foot well screen with 0.010-inch slots, and will be placed to monitor the most permeable portion of the LHSU unit of interest. If insufficient sandstone thickness is present in the target screened interval, a shorter well screen may be installed. The bottom of the well casing will consist of a 3-foot blank casing with a threaded PVC plug to act as a sump at the bottom of the well. Following placement of the well casing and screen, a sand filter pack (No. 16-40 size sand) will be placed within the borehole annulus surrounding the well screen. The sand filter pack will extend from the bottom of the borehole to the top of the permeable unit to be monitored. A minimum 2-foot thick bentonite seal will be placed on top of the sand filter pack to seal the screened interval from the rest of the borehole annulus. Following placement of the bentonite seal, the remainder of the borehole annulus will be grouted to ground surface. The well will be completed with a steel surface protective casing with a locking lid. Monitoring well installation will be in accordance with SOP GT.6, Monitoring Well and Piezometer Installation.

2.4 WELL DEVELOPMENT AND GROUNDWATER SAMPLING

Each monitoring well will be developed to remove fluids or materials potentially introduced during well installation activities, and to allow collection of groundwater samples representative of surrounding groundwater quality. Well development will be initiated a minimum of 48 hours following completion of grouting of the well annulus to ensure proper curing of the grout seal. Monitoring well development will be in accordance with SOP GW.2, Well Development. In the event that well development is excessively slow due to low water yield from LHSU sandstones, the well development procedures in SOP GW.2 may be modified by a DCN to allow collection of groundwater samples in a timely manner for the purposes of identifying whether indicator parameters are present. Wells that cannot be developed within a 4 week period will be monitored under the RFP site-wide groundwater monitoring program.

Following well development, groundwater from each monitoring well will be sampled and the groundwater samples submitted to the analytical laboratory for analysis. The groundwater samples will be collected in accordance with SOP GW.06, Well Sampling and will be handled in accordance with SOP FO.13, Containerization, Preserving, Handling, and Shipping of Soil and Water Samples. Analysis of groundwater samples is discussed in Section 2.7.4.

2.5 HYDRAULIC TESTING

Field hydraulic testing (slug testing) will be conducted at each newly-installed LHSU bedrock monitoring well to estimate the hydraulic conductivity of the LHSU unit. Slug testing will be in accordance with SOP GW.4, Slug Tests. In the event that slug testing is excessively slow due to low water yield from LHSU sandstones, the slug testing procedures in SOP GW.4 may be modified by a DCN.

2.6 EQUIPMENT DECONTAMINATION

Equipment decontamination will be conducted on all drilling and sampling equipment utilized in the Revised Bedrock field investigation program. Either a full or a partial decontamination procedure will be performed depending on the type of equipment and the location of the field activity. All sample collection equipment will be decontaminated between sampling events in accordance with SOP FO.3, General Equipment Decontamination.

Full decontamination consists of decontamination of the entire drilling rig and associated equipment in accordance with SOP FO.4, Heavy Equipment Decontamination. Associated equipment consist of augers, drilling rods and bits, bolts, racks, tools, and sample decontamination tubs. Full decontamination will be performed prior to crossing a decontamination boundary as shown on Figure 2-10, to prevent cross-contamination between the different IHSS areas.

Partial decontamination consists of decontamination of downhole drilling equipment and the back of the drilling rig. Partial decontamination will be performed prior to moving between sampling locations within a decontamination zone (i.e., when moving does not involve crossing a decontamination boundary).

2.7 SAMPLE ANALYSIS

This section discusses the laboratory analysis parameters and methods to be used for rock and groundwater samples. Section 2.7.1 discusses the analysis of borehole claystone samples for SB-1 and SB-2, Section 2.7.2 discusses the analysis of drill cuttings characterization samples, Section 2.7.3 discusses geotechnical analysis of samples collected from pilot boreholes, and Section 2.7.4 discusses analysis of groundwater samples.

2.7.1 Borehole Claystone Samples from SB-1 and SB-2

The vertical extent of contamination in the LHSU at locations SB-1 and SB-2 will be evaluated by collecting analytical samples from the LHSU claystone. As stated in Section 2.3.1, discrete samples for VOC analysis will be obtained every 4 feet and composite samples for analysis for other LHSU parameters will be collected over a 6-foot interval. The borehole analytes for SB-1 and SB-2 are listed in Table 2-4. Approximately 15 VOC samples and 10 composite samples will be obtained from the borehole locations.

The borehole analyte list is a refinement of the full analytical parameter list used for the Alluvial Work Plan investigation, and is based on a review of the contaminants that were detected in the UHSU during the Alluvial Work Plan investigation. In general, parameters were eliminated from the Revised Bedrock Work Plan borehole analyte list for the following reasons: 1) they were not detected at a frequency of greater than 5 percent during the Alluvial Work Plan investigations; 2) they are not believed to be present in on-site wastes; or 3) they were only detected in UHSU samples at levels indicative of sampling/laboratory artifacts.

2.7.2 Drill Cuttings Characterization Samples

Drill cuttings characterization will be based on analyses performed on drill cuttings samples. One sample will be collected for each four drums of cuttings and will be analyzed for VOCs.

Samples submitted for laboratory analysis for drill cuttings characterization will be handled and analyzed in accordance with SOP FO.13, Containerization, Preserving, Handling and Shipping of Soil and Water Samples. Drill fluids, drill cuttings, and recovered formation groundwater will be handled in accordance with SOP FO.10, Receiving, Labeling, and Handling Environmental Materials Containers, pending drill cutting and fluid characterization analytical results.

2.7.3 Pilot Borehole Geotechnical Samples

The permeability and other physical characteristics of the LHSU bedrock units will be evaluated by performing geotechnical laboratory tests on core samples from the pilot boreholes. Geotechnical analyses on bedrock core samples will consist of permeability analyses (vertical and horizontal), porosity, moisture content, bulk density, and grain size distribution (including hydrometer analysis).

TABLE 2-4
LHSU ANALYTICAL PARAMETERS FOR BOREHOLE SAMPLES

METALS
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

OTHER METALS
Molybdenum
Cesium
Strontium
Lithium
Tin

GENERAL PARAMETERS
pH
Cyanide
Moisture Content

RADIONUCLIDES
Gross Alpha
Gross Beta
Uranium 233+234, 235 and 238
Americium 241
Plutonium 239+240
Tritium

ORGANICS: VOLATILES
Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
total 1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Ethyl Benzene
Styrene
Total Xylenes
Tetrachloroethene
Toluene
Chlorobenzene

The sampling frequency within each borehole will be determined by the field geologist and will be based on lithologic variations that are observed within that borehole. It is anticipated that at least five or six samples will be collected from each pilot borehole for geotechnical testing.

2.7.4 Groundwater Samples

Two sets of groundwater samples will be analyzed as part of the Revised Bedrock Work Plan field investigation program. One set will be submitted to an analytical laboratory for analysis on a quick turn-around basis (24 hours) for a suite of indicator parameters selected for their utility and reliability as indicators of site-related contamination. The results from these analyses will be used to guide the scope of the remaining field investigation activities by providing preliminary information on the occurrence and vertical extent of contamination in the LHSU, if it exists, as the field work progresses. The second set of samples will be submitted to a second analytical laboratory for analysis for a more extensive suite of LHSU analytical parameters to confirm the results of the indicator parameter analyses, and to fully characterize the types of contaminants present at a particular LHSU location. Table 2-5 summarizes the groundwater samples to be submitted for laboratory analysis.

2.7.4.1 Indicator Parameter Analysis Suite

One set of groundwater samples from each newly-installed LHSU monitoring well will be submitted to the analytical laboratory for analysis of a suite of indicator parameters to provide preliminary information on the presence or absence of contaminants in the LHSU unit being monitored. The sole purpose of this analysis will be to indicate whether contamination is present or absent in the LHSU unit at a particular location. Based on the results of those analyses, additional field activities (i.e., installation of additional deeper wells) may be performed at the location.

Because the purpose of these analyses is to provide a screening level assessment of the presence or absence of contamination, a suite of indicator parameters was selected that would provide a reliable, unambiguous indication of contamination, if it was present. This approach is analogous to the use of indicator parameters for detection monitoring at a RCRA facility, where the goal is to identify whether site-related contamination exists, rather than to fully characterize the types of contaminants present.

The following factors should be considered when selecting indicator parameters:

TABLE 2-5

SUMMARY OF GROUNDWATER SAMPLES TO BE COLLECTED FOR ANALYSIS

Well Number	No. of Samples	Analysis
WC-1a	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-1b (if installed)	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-2a	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-2b (if installed)	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-3a	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-3b (if installed)	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-4a	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-4b (if installed)	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-5a	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-5b (if installed)	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-6a	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
WC-6b (if installed)	1	Indicator Parameter Suite
	1	LHSU Parameter Analysis Suite
QA/QC Samples	2	Indicator Parameter Suite
	2	LHSU Parameter Analysis Suite
Duplicate Samples	2	Indicator Parameter Suite
	2	LHSU Parameter Analysis Suite
Travel Blanks	1 per cooler containing VOC samples	VOCs
Equipment Blanks	*	Indicator Parameter Suite
	*	LHSU Parameter Analysis Suite

* Equipment blanks will be collected at a frequency of 1 blank per 20 investigative samples or once per day, whichever is more frequent.

- Indicator parameters should consist of constituents that have been detected in on-site waste or existing groundwater contamination at substantial concentrations.

- Indicator parameters should be mobile and relatively stable and persistent over the flow path of interest.

- Indicator parameters should be measurable at low concentrations and should be unambiguous with respect to indication of site-related contamination versus sampling or laboratory artifacts.

- Indicator parameters should be readily discernable at low levels from naturally occurring conditions so as to be unambiguous with respect to indication of site-related contamination versus fluctuations in natural background groundwater quality.

Based on these considerations, the indicator parameter suite to be utilized for the Revised Bedrock Work Plan field investigation program will consist of the halogenated VOCs listed in Table 2-6. These compounds were selected for use as reliable indicator parameters because: 1) they have been detected at high concentrations in source areas and in groundwater in the UHSU; 2) they are expected to be relatively mobile, stable, and persistent over the potential flow path from the UHSU to LHSU units of interest; 3) they are measurable at low concentrations and are unambiguous with respect to sampling and laboratory artifacts; and 4) if detected, they are indicative of site-related contamination because they do not normally occur naturally in groundwater systems.

Table 2-7 lists the groundwater analytical parameters that were specified in the Alluvial Work Plan investigation (EG&G 1991b). With the exception of certain VOCs (i.e., those selected as indicator parameters above, as listed in Table 2-6), the constituents listed in Table 2-7 were not selected for use as indicator parameters for the Revised Bedrock Work Plan due to one or more of the following reasons: 1) they have not been detected at frequencies greater than 5 percent in source areas or in UHSU groundwater (e.g., semi-volatile compounds, certain metals, pesticides, PCBs, radionuclides other than americium, uranium, and plutonium) or, where detected, are believed to be sampling/laboratory artifacts (e.g., acetone, bis-2-ethylhexyl-phthalate, 2-butanone, 2-hexanone, methylene chloride, and other phthalates); 2) they are not

TABLE 2-6

SUMMARY OF GROUNDWATER INDICATOR PARAMETERS FOR REVISED BEDROCK WORK PLAN

HALOGENATED VOLATILE ORGANICS
Vinyl Chloride
1,1-Dichloroethene
total 1,2-Dichloroethene
1,1,1-Trichloroethane
Carbon tetrachloride
Trichloroethene
Tetrachloroethene

TABLE 2-7

SUMMARY OF ALLUVIAL WORK PLAN GROUNDWATER ANALYTICAL PARAMETERS

METALS (Dissolved)*
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

ANIONS
Carbonate*
Bicarbonate*
Chloride*
Sulfate*
Nitrate as N
Cyanide
Fluoride
Bromide
Silica (as Si and SiO_2)
Ammonium
Orthophosphate

OTHER METALS*
Molybdenum
Strontium
Cesium
Lithium
Tin

FIELD PARAMETERS
pH*
Specific Conductance*
Temperature*
Dissolved Oxygen

INDICATORS
Total Dissolved Solids*
Total Organic Carbon*
Dissolved Organic Carbon
pH*

OTHER PARAMETERS
Total Petroleum Hydrocarbons

DISSOLVED RADIONUCLIDES
Gross Alpha*
Gross Beta*
Uranium - 233+234, 235, and 238*
Americium - 241 (surface water only)*
Plutonium - 239+240 (surface water only)*
Tritium
Strontium - 89,90
Cesium 137
Radium 226, 228
Tritium

TOTAL RADIONUCLIDES
Plutonium - 239+240*
Americium - 241*
Tritium

TABLE 2-7

SUMMARY OF ALLUVIAL WORK PLAN GROUNDWATER ANALYTICAL PARAMETERS (Continued)

ORGANICS: VOLATILES*
Chloromethane
Bromomethane
Vinyl Chloride**
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene**
1,1-Dichloroethane
total 1,2-Dichloroethene**
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane**
Carbon tetrachloride**
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene**
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene**
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

ORGANICS: SEMI-VOLATILES
Phenol
bis (2-Chloroethyl) ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropyl)ether
4-Methylphenol
N-Nitroso-Dipropylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic Acid
bis(2-Chloroethoxy)methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol
(para-chloro-meta-cresol)
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloroaphthalene
2-Nitroaniline
Dimethylphthalate
Acenaphthylene
3-Nitroaniline

TABLE 2-7

SUMMARY OF ALLUVIAL WORK PLAN GROUNDWATER ANALYTICAL PARAMETERS (Concluded)

ORGANICS: SEMI-VOLATILES (Cont.)	ORGANICS: PESTICIDES/PCBs
Acenaphthene	alpha-BHC
2,4-Dinitrophenol	beta-BHC
4-Nitrophenol	delta-BHC
Dibenzofuran	gamma-BHC (Lindane)
2,4-Dinitrotoluene	Heptachlor
2,6-Dinitrotoluene	Aldrin
Diethylphthalate	Heptachlor Epoxide
4-Chlorophenyl Phenyl ether	Endosulfan I
Fluorene	Dieldrin
4-Nitroaniline	4,4'-DDE
4,6-Dinitro-2-methylphenol	Endrin
N-nitrosodiphenylamine	Endosulfan II
4-Bromophenyl Phenyl ether	Endosulfan Sulfate
Hexachlorobenzene	4,4'-DDD
Pentachlorophenol	4,4'-DDT
Phenanthrene	Endrin Ketone
Anthracene	Methoxychlor
Di-n-butylphthalate	alpha-Chlordane
Fluoranthene	gamma-Chlordane
Pyrene	Toxaphene
Butyl Benzylphthalate	AROCLOR-1016
3,3'-Dichlorobenzidine	AROCLOR-1221
Benzo(a)anthracene	AROCLOR-1232
bis(2-ethylhexyl)phthalate	AROCLOR-1242
Chrysene	AROCLOR-1248
Di-n-octyl Phthalate	AROCLOR-1254
Benzo(b)fluoranthene	AROCLOR-1260
Benzo(k)fluoranthene	
Benzo(a)pyrene	
Indeno(1,2,3-cd)pyrene	
Dibenz(a,h)anthracene	
Benzo(g,h,i)perylene	

* These parameters included in Revised Bedrock Work Plan LHSU parameter analytical suite (Table 2-9).

** These parameters included in Revised Bedrock Work Plan indicator parameter suite (Table 2-7).

believed to be present in on-site wastes (e.g., chlorides, nitrates); 3) they are generally less mobile than VOCs (e.g., certain metals, radionuclides); and 4) they may occur naturally at low concentrations in groundwater systems (e.g., certain metals and radionuclides).

The selected VOC indicator parameters listed in Table 2-6 will be analyzed by EPA Method 8010. Groundwater samples to be analyzed for indicator parameters will be submitted for analytical laboratory analysis on a 24-hour turn-around basis so that the analytical results can be used to guide the field investigation work. With the time required for the radiation screen analysis for samples shipped off site, and travel time between the site and laboratory, it is expected that 72 hours will pass between the time of sample shipment and receipt of analytical data.

A set of QA/QC samples will also be submitted with the groundwater samples to meet the QA/QC requirements of the project. The number of QA/QC duplicate samples will be equal to 20 percent of the groundwater samples submitted for the project. QA/QC requirements and procedures are discussed in Section 3.0.

2.7.4.2 <u>LHSU Parameter Analysis Suite</u>

In addition to the indicator parameter samples, a second set of groundwater samples will be collected from each newly-installed LHSU monitoring well. This set of samples will be sent to a second analytical laboratory for analysis for a more extensive suite of LHSU analytical parameters (hereafter referred to as the LHSU parameter analytical suite). The purpose of these analyses will be to verify the conclusions drawn based on the results of the indicator to characterize the full range of contaminants present in a LHSU unit, if contamination is indicated.

Table 2-8 lists the LHSU parameter analytical suite selected for the Revised Bedrock Work Plan field investigation program. This list is a refinement of the full analytical parameter list used for the Alluvial Work Plan investigation (Table 2-7), and is based on a review of the contaminants that were detected in the UHSU during the Alluvial Work Plan investigations. The following parameters which were part of the Alluvial Work Plan investigation parameter list, have been eliminated from the LHSU parameter analysis suite:

- Semi-volatile organic compounds (not detected in UHSU samples at a frequency greater than 5 percent with the exception of certain phthalates, which are common laboratory/sampling contaminants)

TABLE 2-8

SUMMARY OF LHSU PARAMETER ANALYTICAL SUITE FOR GROUNDWATER SAMPLES FOR REVISED BEDROCK WORK PLAN

METALS (Dissolved)
Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc
Lithium
Tin

OTHER METALS
Molybdenum
Cesium
Strontium
Lithium
Tin

OTHER PARAMETERS
pH
Specific Conductance
Temperature
Total Dissolved Solids
Cations/Anions
Cyanide
Total Organic Carbon

DISSOLVED RADIONUCLIDES
Gross Alpha
Gross Beta
Uranium 233+234, 235 and 238 (Dissolved)
Americium 241 (Dissolved)
Plutonium 239+240 (Dissolved)
Tritium

ORGANICS: VOLATILES
Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
total 1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon tetrachloride
Vinyl Acetate
Bromodichloromethane
1,1,2,2-Tetrachloroethane
1,2-Dichloropropane
trans-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
cis-1,3-Dichloropropene
Bromoform
2-Hexanone
4-Methyl-2-pentanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

- Pesticides and PCBs (not detected in UHSU samples at a frequency greater than 5 percent)

- Chloride, nitrate, and nitrite (not believed to be present in on-site wastes and/or not detected in UHSU samples at frequencies greater than 5 percent)

- Cesium 137, strontium 89 +90, and radium 226+228, (not believed to be present in on-site wastes based upon the 1992 Historical Release Report)

Table 2-9 lists the analytical methods, sample containers, sample preservation, and sample holding times to be used for analysis of source borehole and groundwater samples for the LHSU parameter analytical suite. The LHSU parameter analytical suite samples will be submitted for analysis under normal turn-around times as dictated in the GRRASP. A set of QA/QC samples will also be submitted with the groundwater samples to meet the QA/QC requirements of the project. The number of QA/QC duplicate samples will be equal to 20 percent of the groundwater samples submitted for the project. QA/QC requirements and procedures are discussed in Section 3.0.

2.8 DATA MANAGEMENT

Field and laboratory data collection during the Revised Bedrock Work Plan field investigation program will be incorporated into the Rocky Flats Environmental Database System (RFEDS). The RFEDS is used to track, store, and retrieve project data. Data (other than indicator parameter analysis results) will be input into the RFEDS via diskette subsequent to data validation as outlined in the ER Program QAPjP (EG&G 1990a) and SOP FO.14, Field Data Management. Hardcopy reports will then be generated from the system for data interpretation and evaluation. The indicator analytical samples will not be incorporated into RFEDS since they will be Level III data and will not be subject to data validation. Indicator parameter analytical results will be submitted to EG&G's subcontractor for inclusion in the OU-2 database. Draft "Logger" logs will be delivered to EG&G within two weeks from EG&G approval of the handwritten borehole logs.

TABLE 2-9
ANALYSIS METHODS, SAMPLE CONTAINERS, SAMPLE PRESERVATION, AND SAMPLE HOLDING TIMES FOR LHSU ANALYTICAL PARAMETERS FOR THE REVISED BEDROCK WORK PLAN

Parameter	EPA Analysis Method or Analysis Reference*	Container	Preservative	Holding Time
Bedrock Samples **Organic Compounds:**				
Volatile Organics	EPA-CLP	1 x 4-oz wide-mouth teflon lined glass vials	Cool, 4°C	14 days
Inorganic Analytes:				
Metals and Other Metals	EPA-CLP	1 x 8-oz wide-mouth glass jar	Cool, 4°C	180 days[1]
Cyanide	335.2 or 335.3	1 x 8-oz wide-mouth glass jar	Cool, 4°C	14 days
pH	9045	1 x 8-oz wide-mouth glass jar	Cool, 4°C	14 days
Moisture Content	A001	1 x 8-oz wide-mouth glass jar	Cool, 4°C	14 days
Radionuclides	see GRRASP	1 x 8-oz wide-mouth glass jar	Cool, 4°C	45 days
Water Samples **Organic Compounds:**				
Volatile Organics	524.2	2 x 40-mL VOA vials with teflon line septum lids	Cool, 4°C[a] with HCl to pH < 2	7 days 14 days
Inorganic Analytes:				
Metals and Other Metals	EPA-CLP	1 x 1-L polyethylene bottle	Nitric acid pH <2; Cool, 4°C	180 days[c]
Cyanide	335.2 or 335.3	1 x 1-L polyethylene bottle	Sodium hydroxide[d] pH > 12; Cool, 4°C	14 days
Anions		1 x 1-L polyethylene bottle	Cool, 4°C	14 days
Cl^-	325.2			
SO_4^{-2}	375.4			
CO_3^{-2}	310.1			
HCO_3^-	310.1			
Cations Na^+, K^+, Mg^{++}, Ca^{++}	EPA-CLP	1 x 1-L polyethylene bottle	Cool, 4°C	180 days
pH	150.1	1 x 1-L polyethylene bottle	Cool, 4°C	28 days

TABLE 2-9
(Concluded)

Parameter	EPA Analysis Method or Analysis Reference*	Container	Preservative	Holding Time
Specific Conductance	120.1	1 x 1-L polyethylene bottle	Cool, 4°C	28 days
Total Dissolved Solids (TDS)	160.1	1 x 1-L polyethylene bottle	Cool, 4°C	48 hours
Total Organic Carbon (TOC)	415.1	1 x 125-ml Amber Glass Bottle	Cool, 4°C	28 days
Radionuclides	see GRRASP	12 x 1-L polyethylene bottle	Nitric acid pH < 2	180 days

[a] Add 0.008 percent sodium thiosulfate (NA_2,S_2,O_3) in the presence of residual chlorine.

[b] Container requirement is for any or all of the parameters given.

[c] Holding time for mercury is 28 days.

[d] Use ascorbic acid only if the sample contains residual chlorine. Test a drop of sample with potassium iodine-starch test paper, a blue color indicates need for treatment. Add ascorbic acid, a few crystals at a time, until a drop of sample produces no color on the indicator paper. Then add an additional 0.6g of ascorbic acid for each L of sample volume.

* EPA-CLP for Organics - U.S. EPA Contract Laboratory Program Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration, 2/88 or latest version.

EPA-CLP for Inorganics - U.S. EPA Contract Laboratory Program Statement of Work for Inorganic Analysis, Multi-Media, Multi-Concentration, 7/88 or latest version.

GRRASP - General Radiochemistry and Routine Analytical Services Protocol. ER Program, Rocky Flats Plant, Golden, CO. August.

analytical results will be submitted to EG&G's subcontractor for inclusion in the OU-2 database. Draft "Logger" logs will be delivered to EG&G within two weeks from EG&G approval of the handwritten borehole logs.

3.0
QUALITY ASSURANCE/QUALITY CONTROL

The SAP addresses the procedures for conducting the proposed field activities as well as the proposed analytical suite for the samples collected during the OU-2 Revised Bedrock Work Plan field program. A Quality Assurance Project Plan (QAPjP) is an element of the SAP that identifies QA objectives for data collection, analytical procedures, calibration, and data reduction, validation, and reporting. The QAPjP, in conjunction with SOPs, completes the SAP. The Environmental Restoration (ER) Program QAPjP and the Rocky Flats (EMD) SOPs have been prepared by EG&G and submitted to the EPA and the CDH for review and comment. All field and analytical procedures will be performed in accordance with the methods described in the QAPjP and SOPs unless otherwise specified in this SAP.

3.1 INTERNAL QC CONTROL SAMPLES

The objective of the QAPjP is to provide a framework to ensure that all sampling and analytical data achieve specific data quality standards. These standards ensure that PARCC parameters (Section 1.2.2.5) for the data are known and documented. All samples sent for CLP Level IV analyses will be handled in accordance with CLP guidelines. QC procedures for non-CLP methods will be developed as needed using standard methods.

QC samples will be collected in conjunction with the investigative samples to provide information on data quality. Equipment rinsate blanks, trip blanks, field duplicates, laboratory blanks, laboratory replicates, and laboratory matrix spike and matrix spike duplicates are the commonly collected samples. Trip blanks generally pertain to only volatile organic analyses; while other QC samples may pertain to all of the analytical parameters specified for investigative samples in the SAP.

Rinsate blanks will be collected by pouring distilled/deionized water through decontaminated sample collection equipment and submitting the sample for the same analyses as the investigative samples. Rinsate blanks monitor the effectiveness of decontamination procedures. Field duplicates will be collected and analyzed to provide information regarding the natural variability of the sampled media as well as evaluate analytical precision. Table 3-1 presents the suggested field QA/QC sample collection frequency.

TABLE 3-1

FIELD QA/QC
SAMPLE COLLECTION FREQUENCY

Activity	Frequency
Field Duplicate	1 in 20*
Trip Blank	1 per cooler containing VOC samples
Equipment Rinsate Blank	1 in 20 or once per day, whichever is more frequent**

* 1 QA/QC duplicate sample collected per every 20 investigative samples collected

** 1 QA/QC equipment blank sample collected per every 20 investigative samples collected, or 1 equipment blank collected per day, whichever is more frequent

Analytical procedures and conditions are tested using laboratory blanks and replicates. Laboratory matrix spikes and matrix spike duplicates measure analytical accuracy by providing data on matrix effects/interferences and components interfering with instrument responses. The frequency of collection and analysis of laboratory QC samples is dictated by the prescribed analytical method as cited in the General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G 1990d).

3.2 ACCURACY

Accuracy is a quantitative measure of data quality which refers to the degree of difference between measured or calculated values and the true value. One of the measures of analytical accuracy is expressed as the percent recovery of a spike which has been added to an environmental sample at a known concentration before analysis (EG&G 1992a). The control limits which have been established to achieve accuracy objectives for Level IV data quality are outlined in Table B1 of Appendix B in the QAPjP (EG&G 1992a). Accuracy limits for both inorganic and organic analytes are listed in that table. Samples requiring 24-hour turnaround (i.e., indicator parameter analyses) have accuracy objectives consistent with Level III data quality. The analyses for indicator parameters are non-CLP. Non-CLP analyses will be conducted according to SW-846 (3rd Ed.) and EPA Methods for Chemical Analyses of Water and Wastes. The accuracy criteria for these samples are specified in the respective methods.

3.3 PRECISION

Precision is a quantitative measure of data quality which refers to the reproducibility or degree of agreement among replicate measurements of a single analyte. Analytical precision for a single analyte may be expressed as a percentage of the difference between results of duplicate samples and matrix spike duplicates for a given analyte (EG&G 1992a). The control limits which have been established to achieve precision objectives for level IV data quality are outlined in Table B1 of Appendix B in the QAPjP (EG&G 1992a). Precision limits for both inorganic and organic analytes are listed in that table. The analyses for indicator parameters are non-CLP. Non-CLP analyses will be conducted according to SW-846 (3rd Ed.) and EPA Methods for Chemical Analyses of Water and Wastes. The precision criteria for these samples are specified in the respective methods.

3.4 SENSITIVITY

Sensitivity defines the lowest concentration (detection limit) a method can accurately and repeatedly detect for particular chemical or compound. The required detection limits for CLP analyses are outlined in Table B1 of Appendix B in the QAPjP (EG&G 1992a) Detection limits for non-CLP indicator parameter analyses shall be those specified in the respective EPA methods.

3.5 REPRESENTATIVENESS

Representativeness is a qualitative measure of data quality defined by the degree to which the data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition (EG&G 1992a). Representativeness is ensured through the careful development and review of the sampling and analysis strategy outlined in the SAP and SOPs for sample collection, analysis and field data collection.

3.6 DATA COMPARABILITY

Comparability is a qualitative measure defined by the confidence with which one data set can be compared to another. Differences in field and laboratory procedures greatly affect comparability. Comparability is ensured by implementation of the SAP, standardized analytical protocols, SOPs for field investigations, and by reporting data in uniform units.

3.7 COMPLETENESS

Completeness is a quantitative measure of data quality expressed as the percentage of valid or acceptable data obtained from a measurement system (EG&G 1992a). The target completeness objective for both field and analytical data for this project is 90 percent, as stated in the Quality Assurance Addendum for Operable Unit No. 2 (Bedrock) (QAA) 2.2 (EG&G 1991a).

3.8 SAMPLE MANAGEMENT

Good sample management is a critical component of the Revised Bedrock Work Plan. It ensures that sample integrity is maintained from sampling through analysis. Sample management, including labelling, sampling, decontamination, preservation/storage, chain of custody and shipping will be conducted in accordance with applicable SOPs, unless otherwise modified as necessary.

3.9 DATA REPORTING

Field data will be collected and reported as outlined in SOP FO.14, Field Data Management. Laboratory data from the 24-hour turnaround samples will be reported in a facsimile transmittal to the on-site manager and EG&G personnel or their designees, in order to facilitate decision making for the observational sampling approach. An electronic transmittal, in RFEDS format, will subsequently be sent to EG&G or their designees for input into the OU-2 database. The EPA-CLP sample results will be reported as specified in the GRRASP and the EG&G "Procedures for Providing the Electronics Deliverable Lab Data to the Rocky Flats Environmental Data Tracking System".

4.0
SCHEDULE

The quantitative assessment of human health risk associated with the UHSU will be conducted concurrently with the Revised Bedrock Work Plan field investigation. It is assumed that the Revised Bedrock Work Plan field investigation results will verify that contamination associated with LHSU exposure pathways is limited and that the LHSU exposure pathway is an incomplete pathway to human receptors. Under this assumption, no quantitative assessment of human health risk associated with the LHSU will be performed for the Draft Phase II RFI/RI Report. If the field results do not support the assumption that the LHSU is an incomplete exposure pathway, a contingency plan will be developed and discussed with the EPA and CDH. The contingency plan will be implemented expeditiously in order to minimize schedule delays.

The schedule for implementation of the Revised Bedrock Work Plan is designed to allow inclusion of the contaminant indicator parameter results in the Draft Phase II RFI/RI Report to EPA and CDH. It is anticipated that most, if not all, of the analytical results for the indicator parameters, and some non-validated results for the LHSU analytical parameters will be included in the contamination assessment portion of the Draft Phase II RFI/RI Report to EPA and CDH. All validated analytical data for the LHSU analytical parameters, including QA/QC results, are anticipated to be available for inclusion in the Final Phase II RFI/RI Report. However, because the expected condition is that the LHSU exposure pathway is incomplete, these data will not be used quantitatively in the human risk assessment.

Geologic, hydrogeologic, and contaminant data collected during the field activities must be available to EG&G or their designated subcontractors on an ongoing basis as field work progresses to allow RFI/RI interpretations to be formulated and revised for inclusion in the RFI/RI Report. To achieve this, the following items will be transmitted to EG&G or their designated subcontractors as field work progresses:

- Weekly field reports in typed form documenting all field activities conducted for that week
- Boring and well completion logs in EG&G computerized format
- Results of geophysical logging and interpretation

- Well development logs in typed form
- Slug test field activity and analysis reports in typed form
- Field sampling reports in typed form
- Copies of laboratory chain-of-custody documentation
- Analytical results in RFEDS format
- Draft "Logger" logs

It is anticipated that the field program will require five to six months to complete. This estimated duration assumes that two hollow-stem auger drill rigs and two mud/air rotary drill rigs capable of HX-size coring will be utilized simultaneously. The schedule also assumes that three weeks (15 working days) are required for development and sampling of each monitoring well, and that total turn-around time for indicator parameter analysis is 72 hours from the end of the day in which samples are collected.

5.0
REFERENCES

ChemRisk, 1992, Reconstruction of Historical Rocky Flats Operations and Identification of Release Points, Tasks 3 and 4. August.

EG&G Rocky Flats, Inc. (EG&G). 1990a. Data Validation Functional Guidelines, Environmental Restoration Department, Environment Monitoring and Assessment Division, Rocky Flats Plant, Golden, Colorado.

EG&G Rocky Flats, Inc. (EG&G). 1990b. Background Geochemical Characterization Report for 1989. December.

EG&G Rocky Flats, Inc. (EG&G). 1990c. Draft Rocky Flats Plant Site-Wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies Activities, ER Program, Rocky Flats Plant, Golden, Colorado. July.

EG&G Rocky Flats, Inc. (EG&G). 1990d. General Radiochemistry and Routine Analytical Services Protocol (GRRASP). ER Program, Rocky Flats Plant, Golden, Colorado. August.

EG&G Rocky Flats, Inc. (EG&G). 1991a. Quality Assurance Addendum for Operable Unit No. 2 (Bedrock), 903 Pad, Mound, and East Trenches Areas Phase II RFI/RI. July.

EG&G Rocky Flats, Inc. (EG&G). 1991b. Final Phase II RFI/RI Work Plan (Alluvial) for Operable Unit No. 2, Technical Memorandum No. 1. August.

EG&G Rocky Flats, Inc. (EG&G). 1991c. Final Phase II RFI/RI Work Plan for Operable Unit No. 1. Revision 1. August.

EG&G Rocky Flats, Inc. (EG&G). 1991d. Background Geochemical Characterization Report. September.

EG&G Rocky Flats, Inc. (EG&G). 1991e. Final Phase II RFI/RI Work Plan (Bedrock) for Operable Unit No. 2. June.

EG&G Rocky Flats, Inc. (EG&G). 1991f. Final Task 3 Shallow, High Resolution Seismic Reflection Profiling in Operable Unit 2. February.

EG&G Rocky Flats, Inc. (EG&G). 1992a. Rocky Flats Plant Site-wide Quality Assurance Project Plan for CERCLA Remedial Investigation/Feasibility Studies Activities, ER Program, Rocky Flats Plant, Golden, Colorado. June.

EG&G Rocky Flats, Inc., (EG&G). 1992b. Final Phase II Geologic Characterization Data Acquisition, Surface Geologic Mapping of the Rocky Flats Plant and Vicinity, Jefferson and Boulder Counties, Colorado. March.

Gilbert, Richard O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Norstrand Reinhold Company, New York.

Hurr, R.T. 1976. Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado. U.S. Geological Survey Open File Report 76-268.

Rockwell International. 1987a. Annual Environmental Monitoring Report: January-December 1986; Rockwell International. Rocky Flats Plant, Golden, Colorado. Report RFP-ENV-86.

Rockwell International. 1987b. Remedial Investigation Report for 903 Pad, Mound, and East Trenches Areas, Vol. III. December.

U.S. Department of Energy (DOE). 1987. Comprehensive Environmental Assessment and Response Program. Phase 2: Rocky Flats Plant Draft Site-Specific Monitoring Plan.

U.S. Department of Energy (DOE). 1992a. Draft Technical Memorandum No. 5, Human Health Risk Assessment, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2, Exposure Scenarios, Rocky Flats Plant, Golden, Colorado. July.

U.S. Department of Energy (DOE). 1992b. Final Historical Release Report for the Rocky Flats Plant, Rocky Flats Plant, Golden, Colorado. June.

U.S. Department of Energy (DOE). 1992c. Final Phase II RFI/RI Aquifer Test Report for Rocky Flats Plant, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2, Vol. I, text. November.

U.S. Department of Energy (DOE). 1993a. Draft Final Technical Memorandum, Addendum to Final Phase II RFI/RI Work Plan, OU2, Surface Soil Sampling and Analysis Plan, Rocky Flats Plant, Golden, Colorado. January.

U.S. Department of Energy (DOE) 1993b. Draft Technical Memorandum No. 6 Human Health Risk Assessment, 903 Pad, Mound, and East Trenches Areas, Operable Unit No. 2, Model Description, Rocky Flats Plant, Golden, Colorado. January.

U.S. Environmental Protection Agency (EPA). 1987. Data Quality Objectives for Remedial Response Activities. EPA 154-IG-871003, OSWER Directive 9355.0-7B. March.

U.S. Environmental Protection Agency (EPA). 1989. Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual-Part A. Office of Emergency and Remedial Response. Washington, DC.

U.S. Environmental Protection Agency (EPA). 1990a. Guidance for Data Usability in Risk Assessment, Solid Waste and Emergency Response. EPA/540/G-90/008.

U.S. Environmental Protection Agency (EPA). 1990b. USEPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, Multi-Media High Concentration. October.

U.S. Environmental Protection Agency (EPA). 1991a. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual - Part B. December.

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000571

Titled: Revised Bed Rock Work Plan Technical Memorandum NO 8 Plate 1-1

Fiche location: A-0402-M1

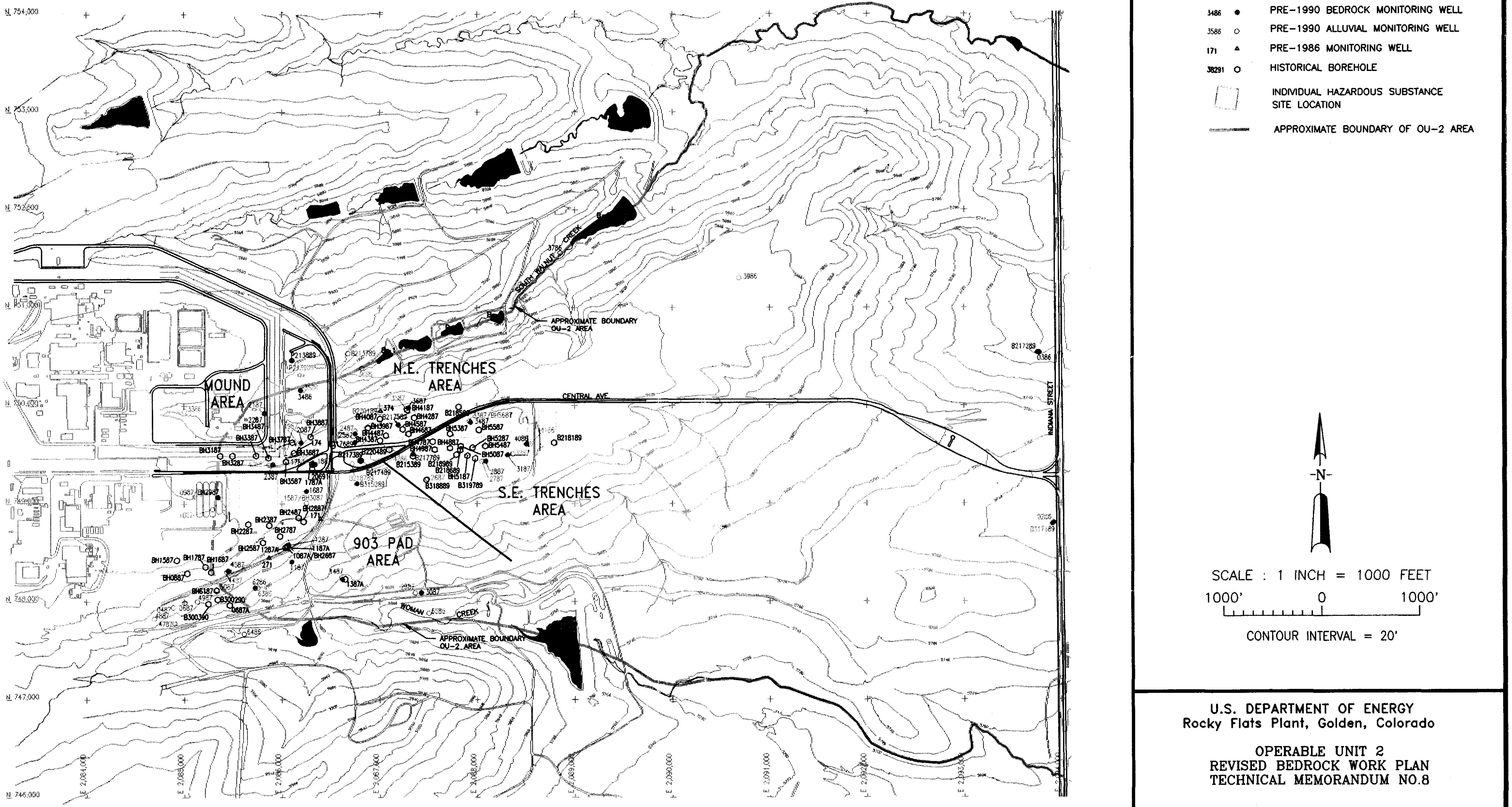
NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000571

Titled: Revised Bedrock work Plan Technical memorandum NO. 8 Plate 1-2

Fiche location: A-0U02-M1



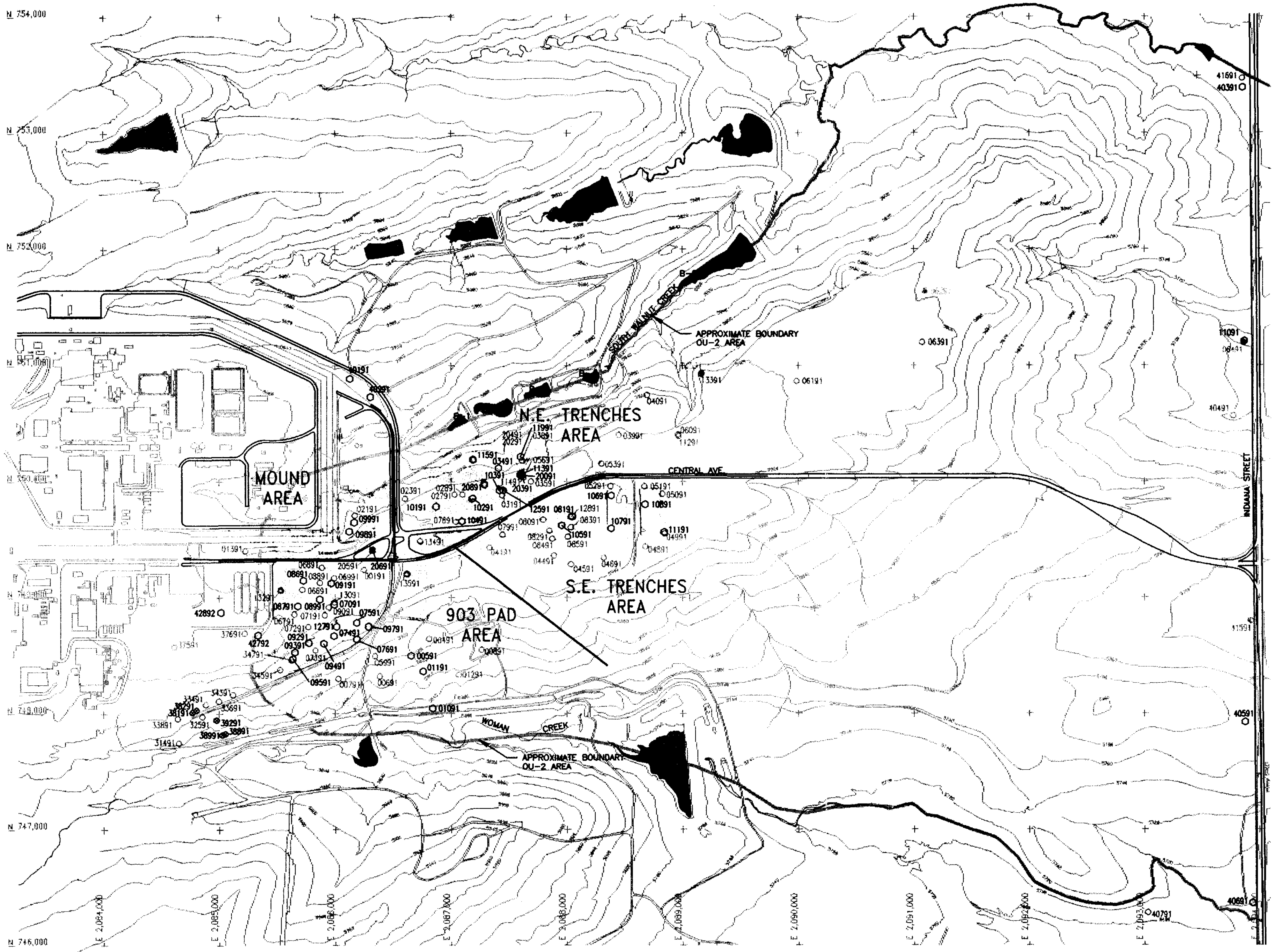
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

PRE-1990 MONITORING WELL AND BOREHOLE LOCATIONS

FIGURE 1-5 MARCH 1993

RFL0051



EXPLANATION

	•	1991–1992 BEDROCK MONITORING WELL
00691	○	1991 ALLUVIAL MONITORING WELL
11191	○	1991 AND 1992 BOREHOLE
38291	⊗	PIEZOMETER
20291	□	ALLUVIAL OBSERVATION WELL
20091	▲	BEDROCK PUMPING WELL
	•	BEDROCK OBSERVATION WELL
		INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
		APPROXIMATE BOUNDARY OF OU-2 AREA

-N-

SCALE : 1 INCH = 1000 FEET

1000' 0 1000'

CONTOUR INTERVAL = 20'

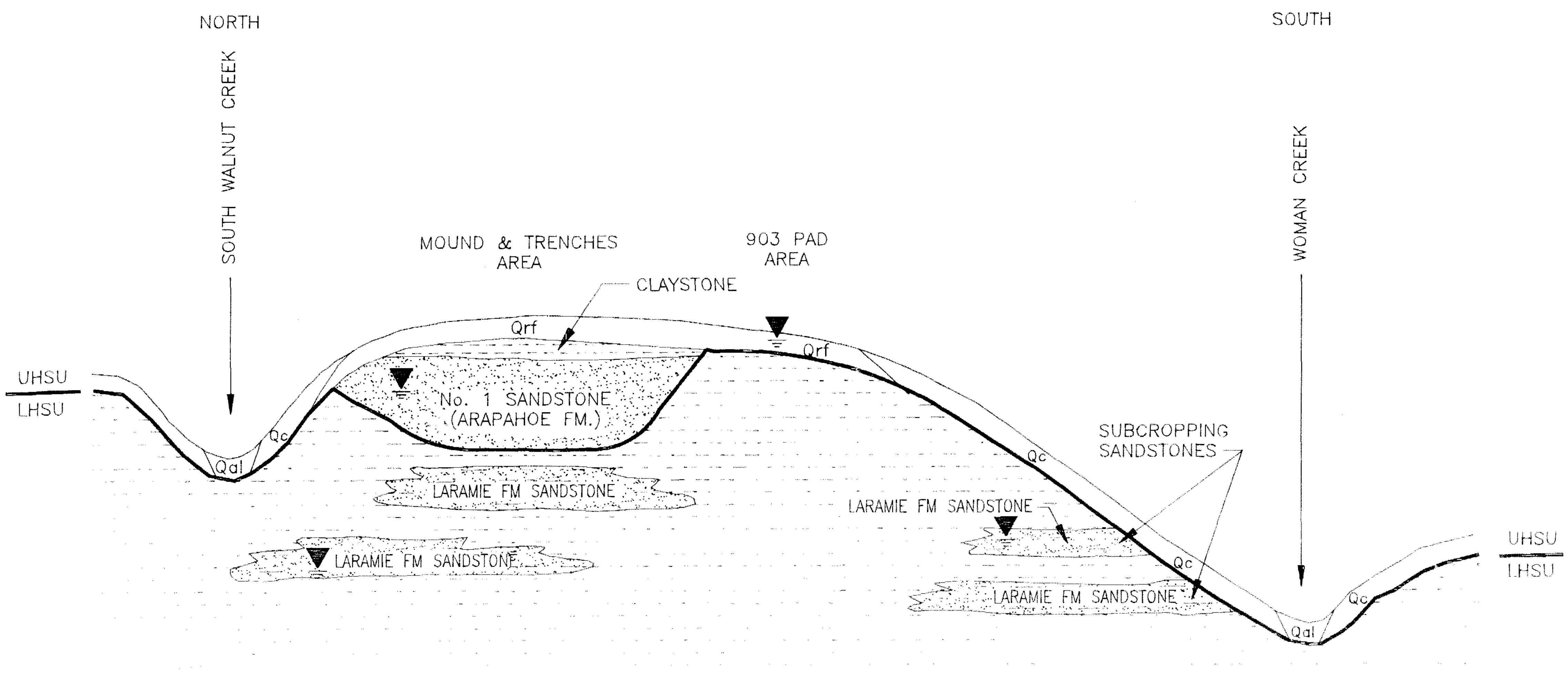
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

1991 AND 1992 MONITORING WELL AND BOREHOLE LOCATIONS

FIGURE 1-6 MARCH 1993

RFL0052



NOTE: NOT TO SCALE

EXPLANATION

Qal	STREAM ALLUVIUM	UHSU
Qc	COLLUVIUM	
Qrf	ROCKY FLATS ALLUVIUM	
No. 1	ARAPAHOE FORMATION SANDSTONE	
LARAMIE FORMATION SANDSTONES		LHSU

BOUNDARY BETWEEN UHSU AND LHSU

SCHEMATIC WATER LEVEL

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

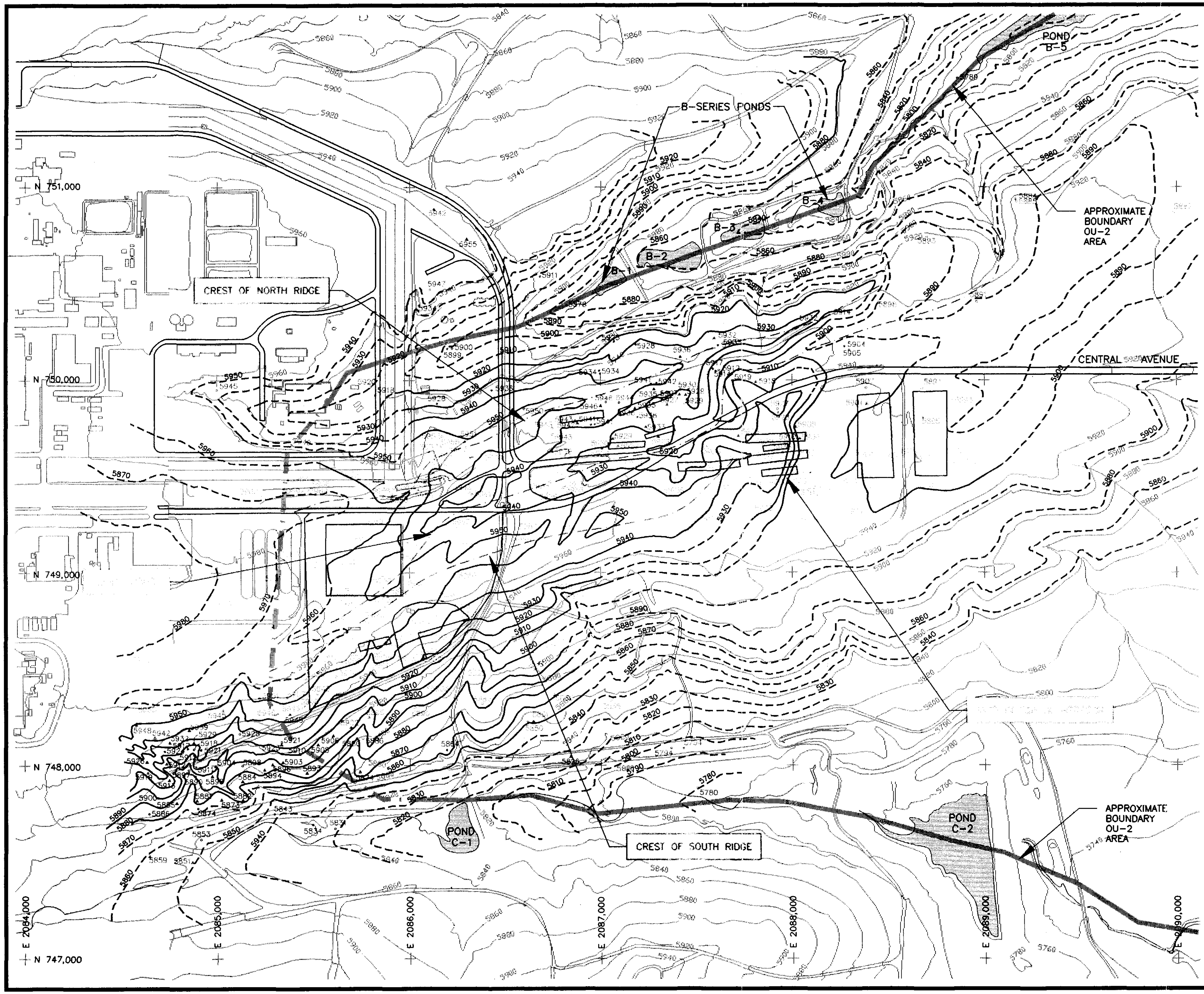
OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

SCHEMATIC DIAGRAM OF THE CONCEPTUAL UHSU AND LHSU BOUNDARY

FIGURE 1-8

MARCH 1993

23067E01



EXPLANATION

BEDROCK MONITOR WELL LOCATION SHOWING ELEVATION (In Feet) OF TOP OF BEDROCK

ALLUVIAL/COLLUVIAL MONITOR WELL LOCATION SHOWING ELEVATION (In Feet) OF TOP OF BEDROCK

BOREHOLE LOCATION SHOWING ELEVATION (In Feet) OF TOP OF BEDROCK

5700 TOP OF BEDROCK (Arapahoe and Laramie Formations) ELEVATION CONTOUR (Dashed Where Approximately Located or Inferred)

APPROXIMATE BOUNDARY OF OU-2 AREA

N

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

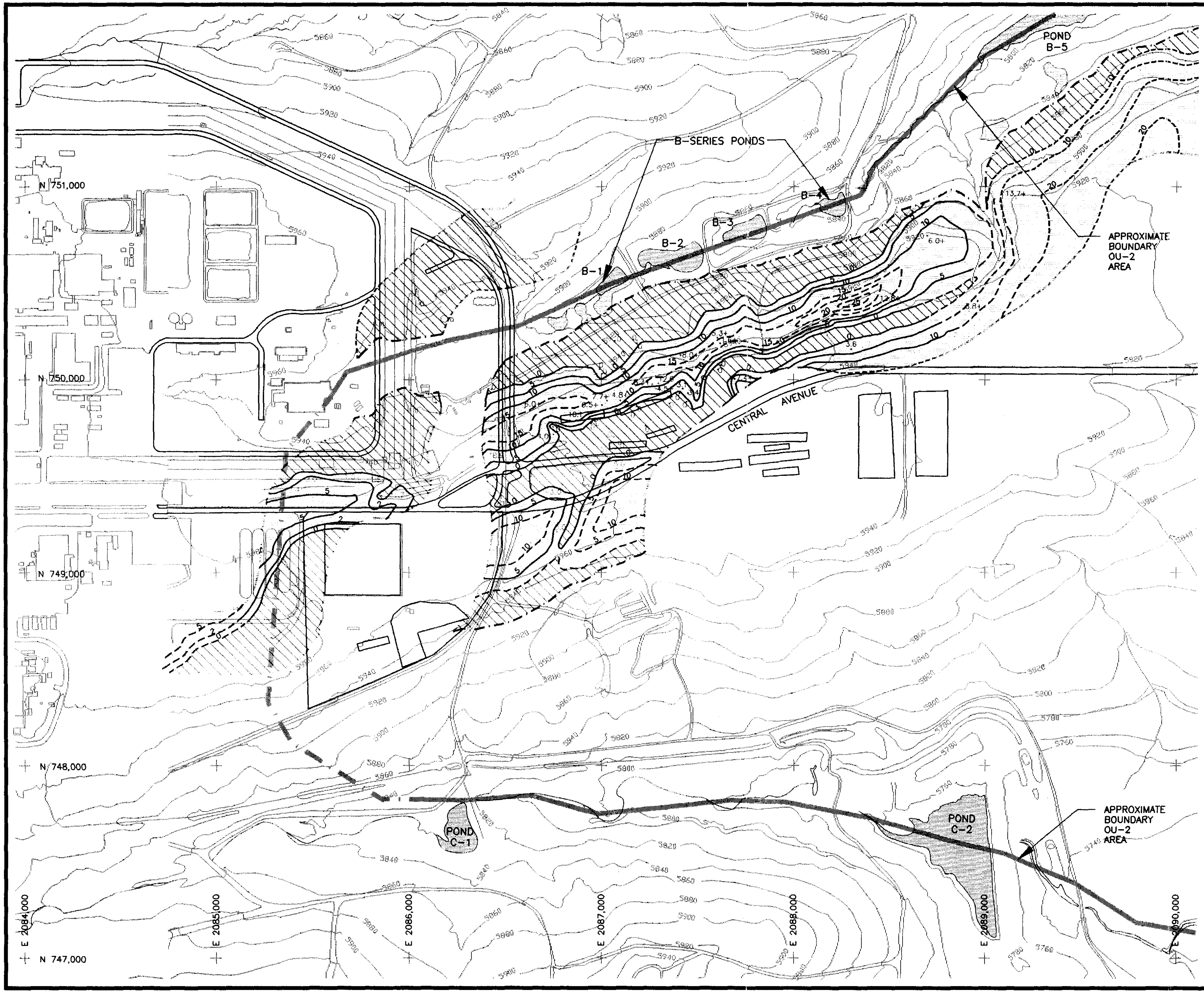
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO.2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

TOP OF BEDROCK
(Arapahoe and Laramie Formations)
BENEATH ALLUVIAL/COLLUVIAL COVER

FIGURE 1-9 MARCH 1993

RFL0056 1=500



EXPLANATION

CONTROL POINT SHOWING THICKNESS (In Feet) OF CLAYSTONE/SILTSTONE LAYER BETWEEN BASE OF ALLUVIUM/COLLUVIUM AND TOP OF NO.1 SANDSTONE

20 THICKNESS CONTOUR (In Feet) OF CLAYSTONE/SILTSTONE LAYER BETWEEN BASE OF ALLUVIUM/COLLUVIUM AND TOP OF NO.1 SANDSTONE (5 Ft. Contour Interval; Dashed Where Approximate or Inferred Thickness)

BOUNDARY OF NO.1 SANDSTONE CHANNEL
(—— Approximate Location)
(- - - Inferred Location)

EROSIONAL LIMIT OF SANDSTONE (i.e., Intersection of Sandstone Bottom and Topography of Hillside)

AREA OF DIRECT CONTACT BETWEEN NO.1 SANDSTONE AND OVERLYING ALLUVIUM/COLLUVIUM

VEGETATED AREAS ASSOCIATED WITH NO.1 SANDSTONE GROUNDWATER SEEPS

APPROXIMATE BOUNDARY OF OU-2 AREA

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

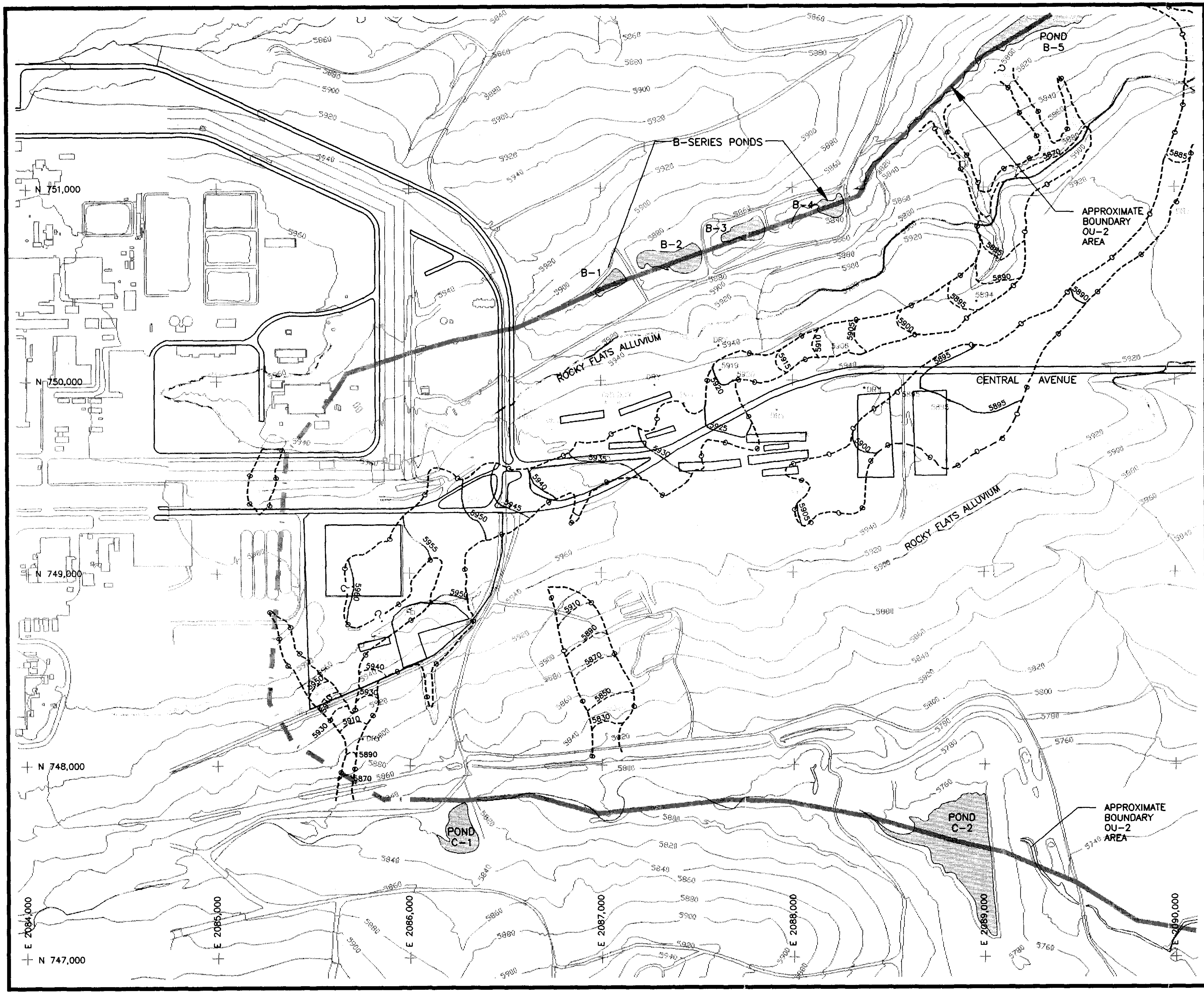
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO.2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

LATERAL EXTENT OF NO.1 SANDSTONE AND CONTACT ZONES WITH OVERLYING ALLUVIUM/COLLUVIUM

FIGURE 1-10 MARCH 1993

RFL0057 1=500



EXPLANATION

ELEVATION (IN FEET) OF POTENTIOMETRIC SURFACE IN ALLUVIAL/COLLUVIAL MONITOR WELL (March, 1991 Measurements)

5900 POTENTIOMETRIC SURFACE ELEVATION CONTOUR (Dashed Where Approximately Located)

EXTENT OF SATURATION IN ALLUVIUM/ COLLUVIUM

AREAL EXTENT OF ROCKY FLATS ALLUVIUM (Dashed Where Approximately Located)

VEGETATED AREAS ASSOCIATED WITH ALLUVIAL GROUNDWATER SEEPS

APPROXIMATE BOUNDARY OF OU-2 AREA

-N-

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

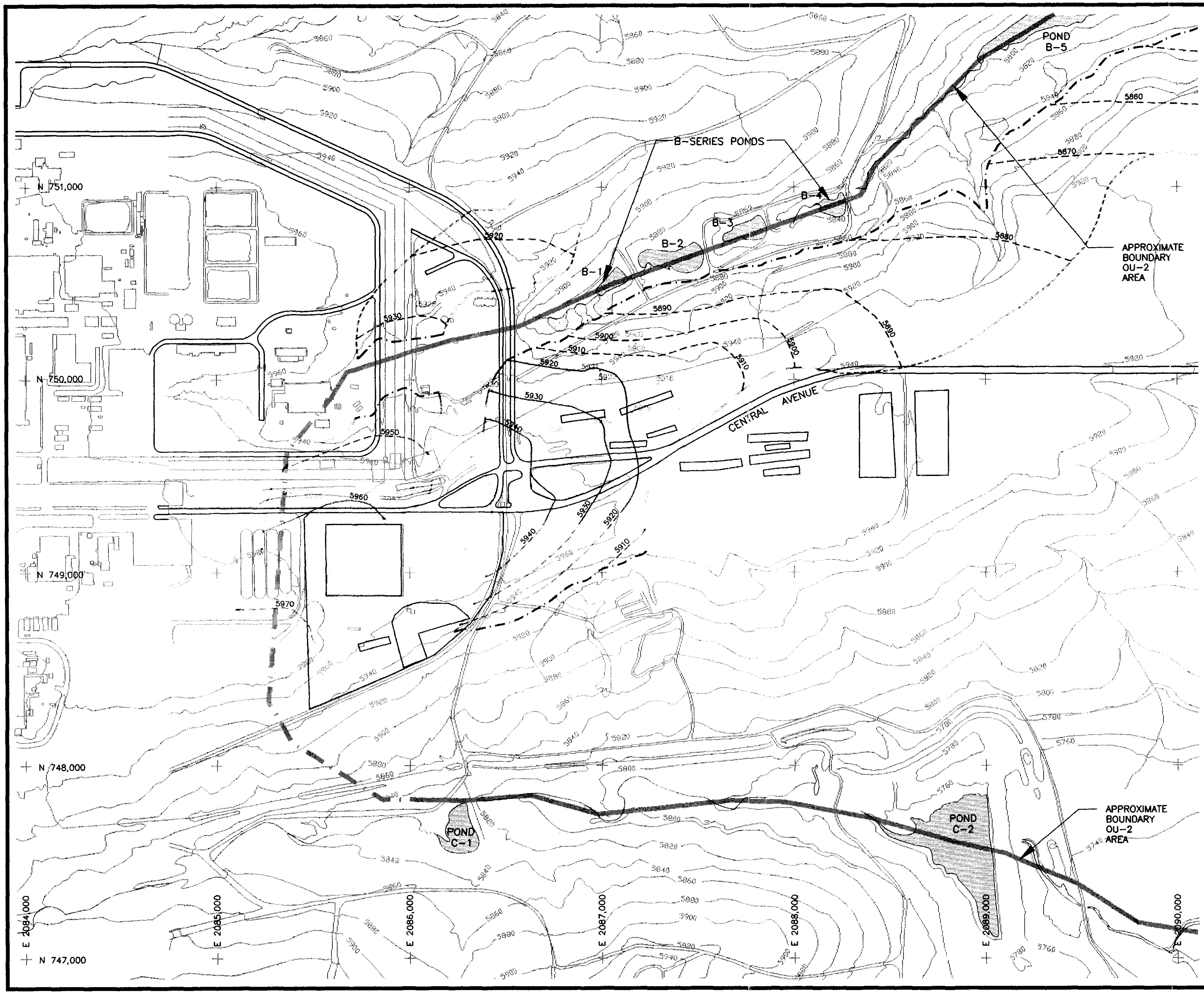
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO.2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

POTENTIOMETRIC SURFACE WITHIN THE ROCKY FLATS ALLUVIUM AND COLLUVIUM UHSU GROUNDWATER FLOW SYSTEM FIRST QUARTER 1992

FIGURE 1-11 MARCH 1993

RFL0058 1=500



EXPLANATION

ELEVATION (In Feet) OF POTENTIOMETRIC SURFACE WITHIN NO.1 SANDSTONE MONITOR WELL (January, 1992 Measurements)

5800 POTENTIOMETRIC SURFACE ELEVATION CONTOUR (Dashed Where Approximately Located or Inferred)

BOUNDARY OF NO.1 SANDSTONE CHANNEL
(— — Approximate Location)
(- · - · - Inferred Location)

EROSIONAL LIMIT OF SANDSTONE (i.e., Intersection of Ss. Bottom and Topography of Hillsides)

VEGETATED AREAS ASSOCIATED WITH NO.1 SANDSTONE GROUNDWATER SEEPS

APPROXIMATE BOUNDARY OF OU-2 AREA

-N-

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

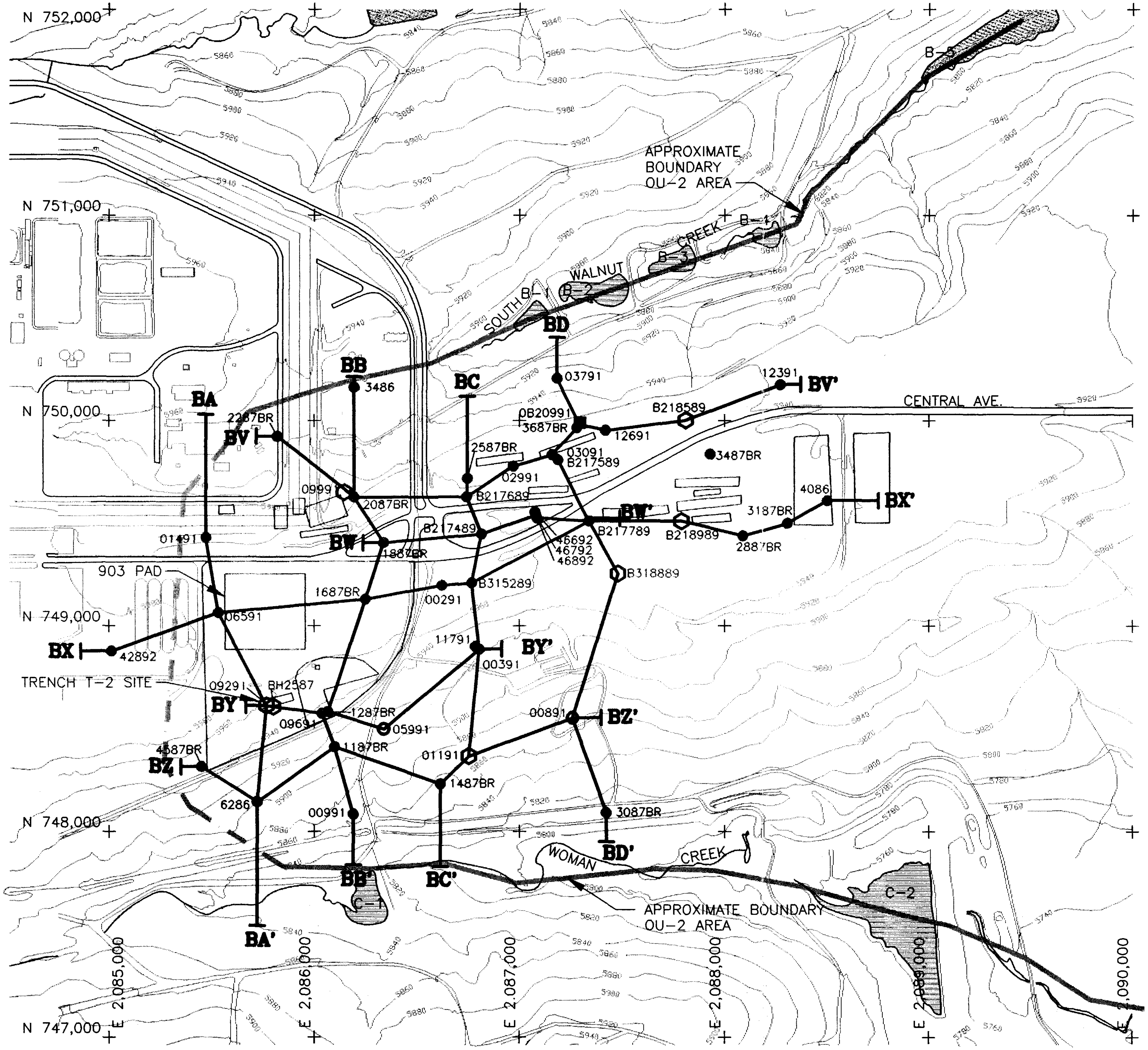
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT NO.2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

POTENTIOMETRIC SURFACE
WITHIN THE NO.1 SANDSTONE
UHSU GROUNDWATER FLOW SYSTEM
FIRST QUARTER 1992

FIGURE 1-12 MARCH 1993

RFL0059 1=500



EXPLANATION

- ALLUVIAL MONITORING WELL
- BEDROCK MONITORING WELL
- BEDROCK OBSERVATION WELL
- BOREHOLE
- GEOLOGIC CROSS-SECTION LINES
- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
- APPROXIMATE BOUNDARY OF OU-2 AREA

-N-

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

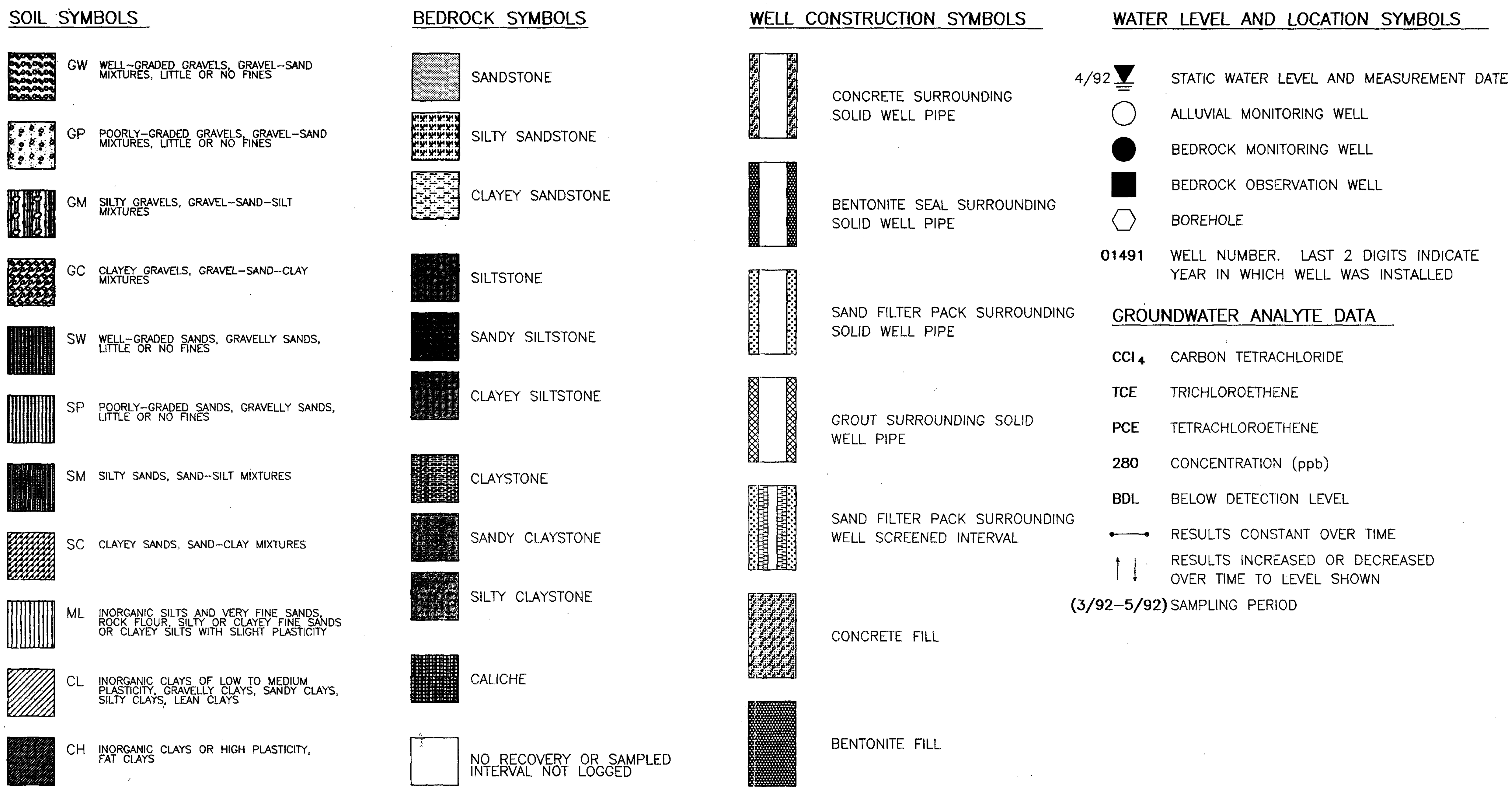
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

LOCATION MAP
GEOLOGIC CROSS-SECTIONS

FIGURE 1-13 MARCH 1993

RFL0071



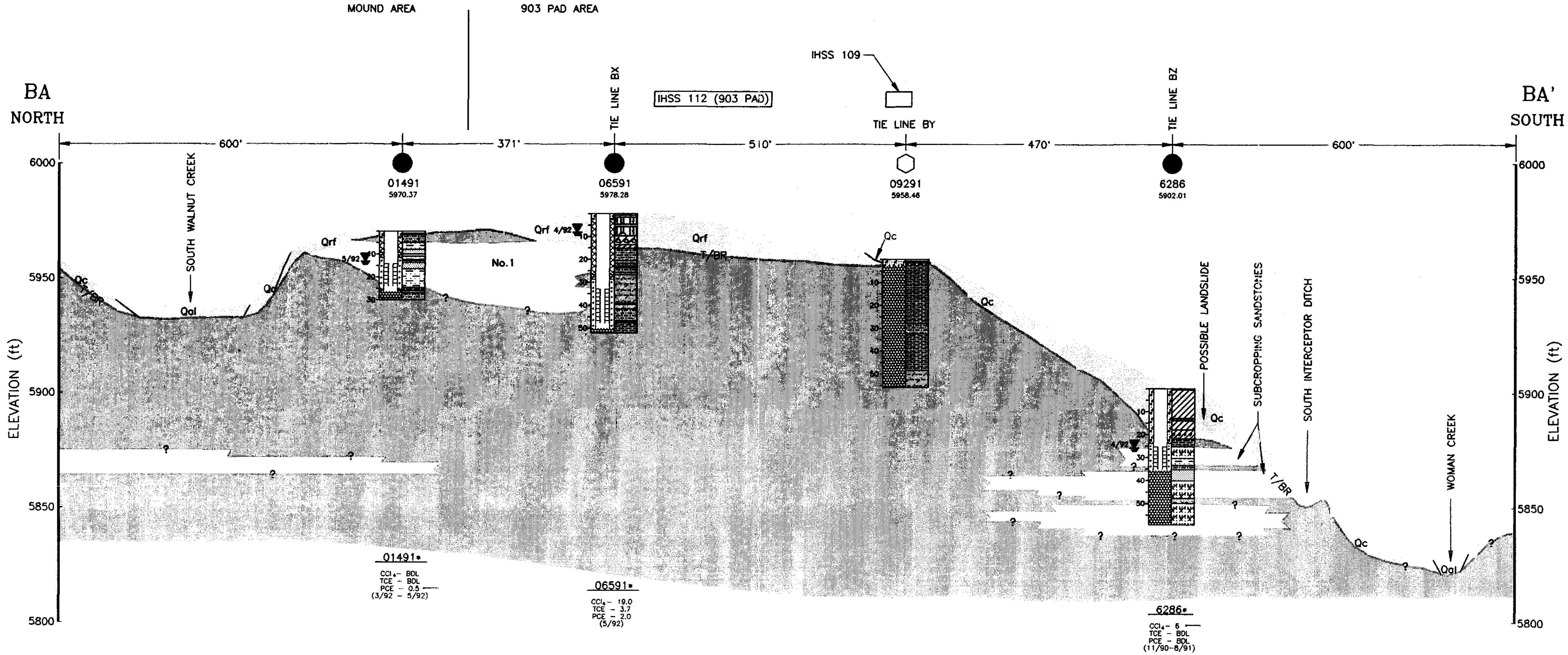
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

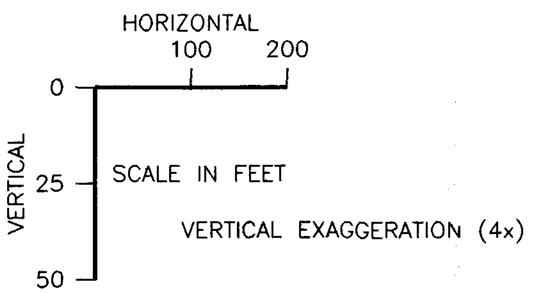
GEOLOGIC CROSS-SECTIONS LEGEND

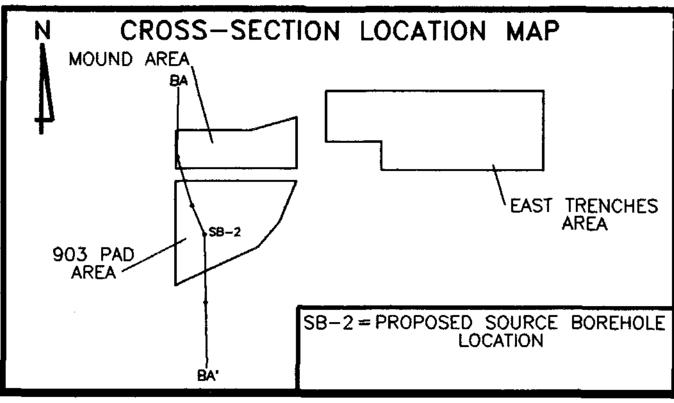
FIGURE 1-14 MARCH 1993

RFL0070



* GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS





EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

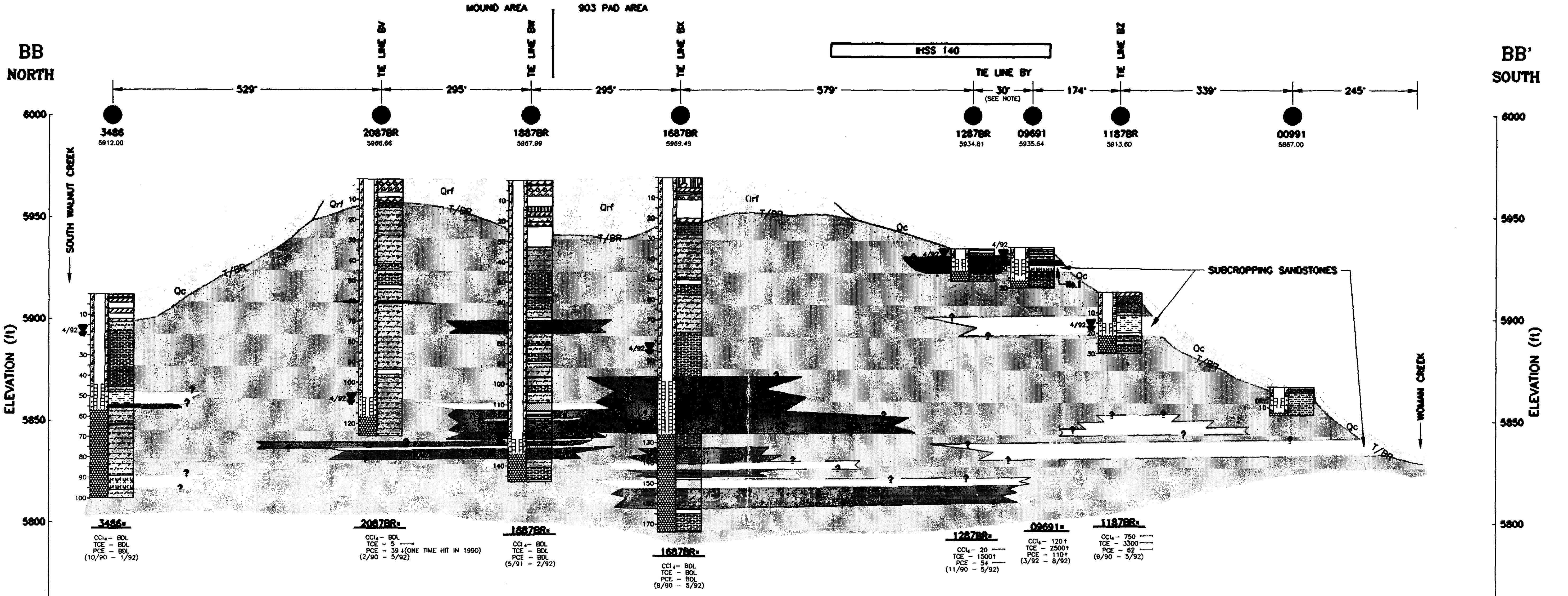
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

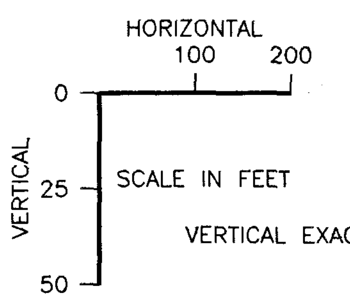
GEOLOGIC CROSS-SECTION BA-BA'

FIGURE 1-15 MARCH 1993

RFL0060

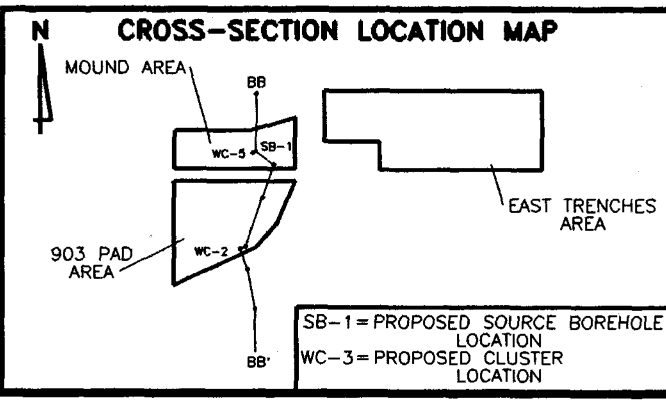


* GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS



NOTE: DISTANCE SHOWN BETWEEN WELLS 1287BR, 09691 IS NOT TO HORIZONTAL SCALE.

CROSS-SECTION LOCATION MAP



SB-1 = PROPOSED SOURCE BOREHOLE LOCATION
WC-3 = PROPOSED CLUSTER LOCATION

EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

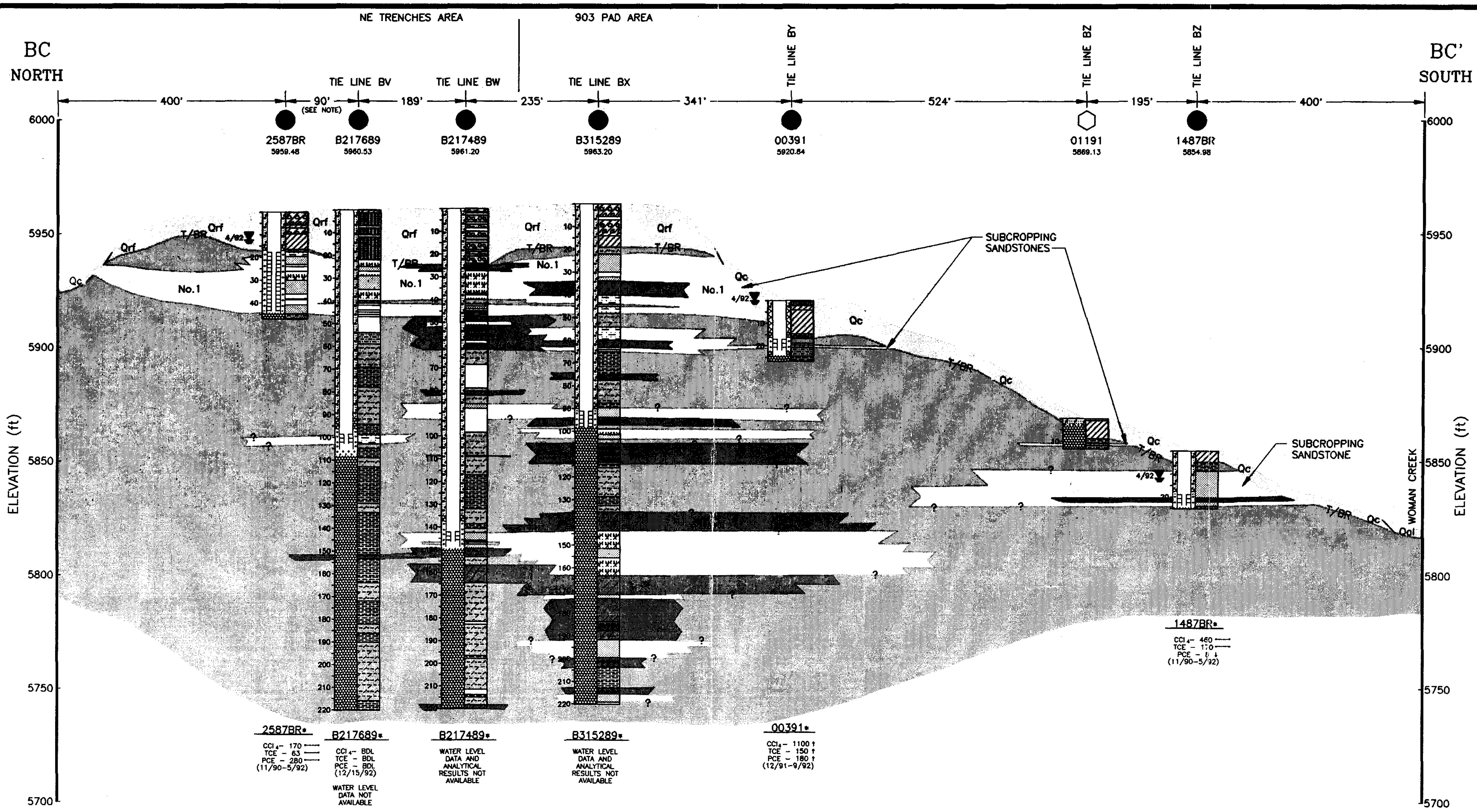
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

GEOLOGIC CROSS-SECTION BB-BB'

FIGURE 1-16 MARCH 1993

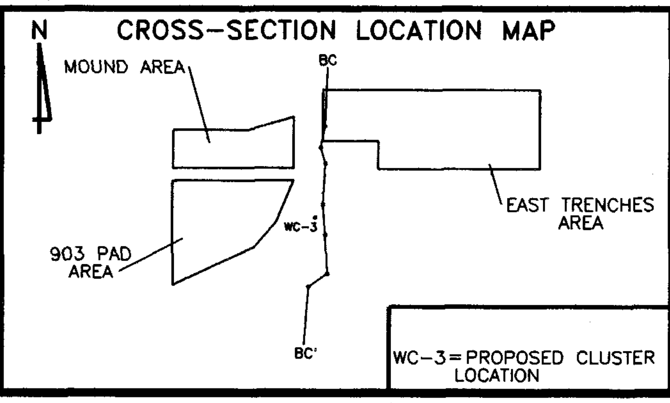
RFL0061



* GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS

HORIZONTAL
100 200
0
25
50
VERTICAL
SCALE IN FEET
VERTICAL EXAGGERATION (4x)

NOTE: DISTANCE SHOWN BETWEEN WELLS 2587BR, B217689 IS NOT TO HORIZONTAL SCALE.



EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

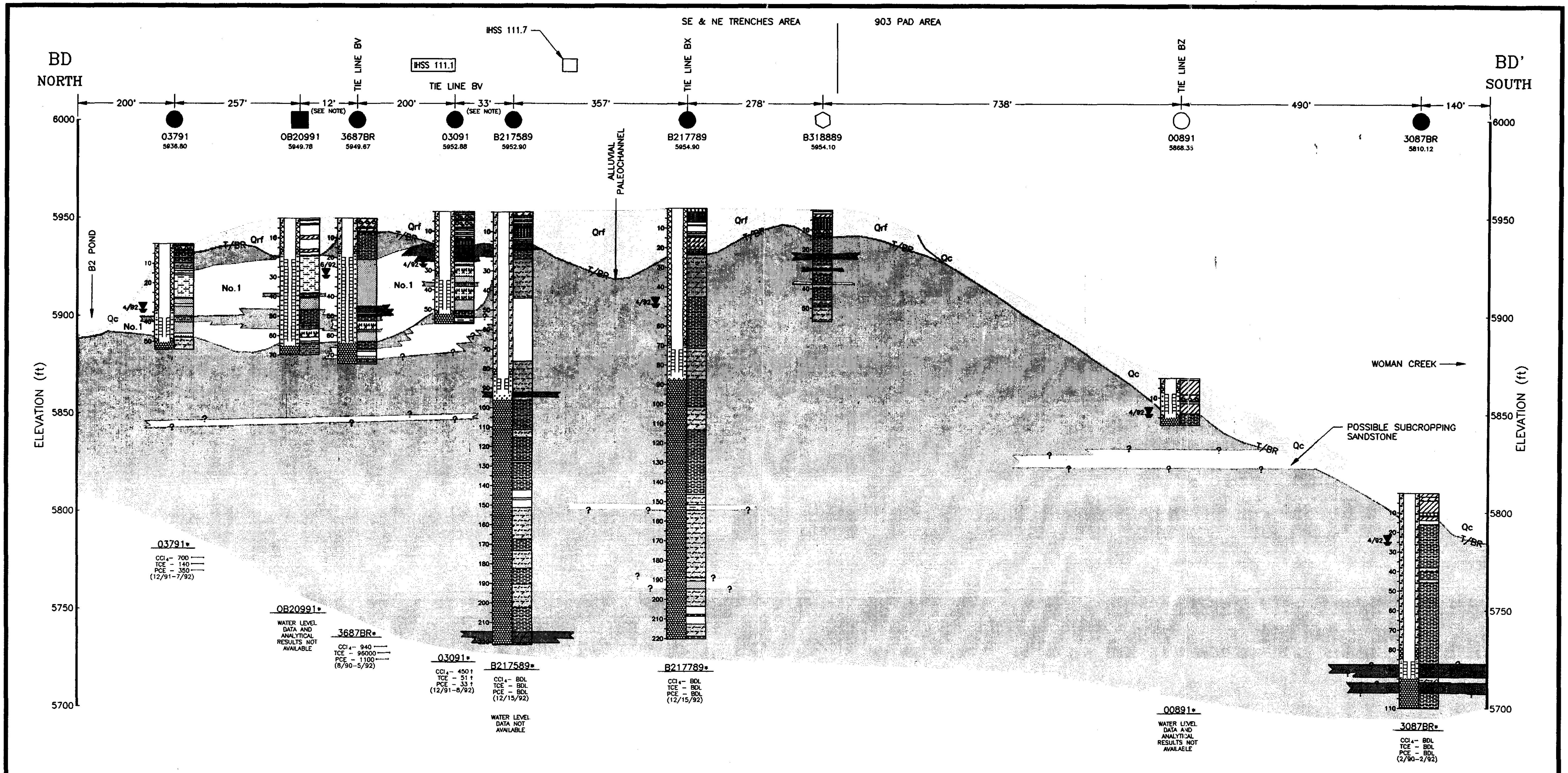
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

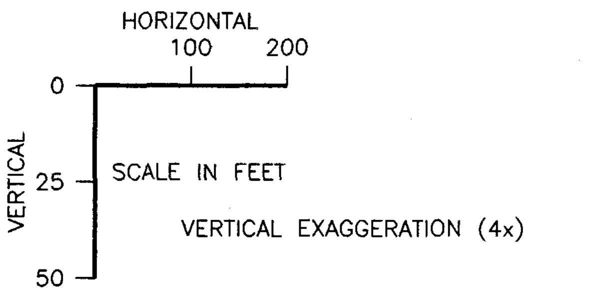
GEOLOGIC CROSS-SECTION BC-BC'

FIGURE 1-17 MARCH 1993

RFL0062

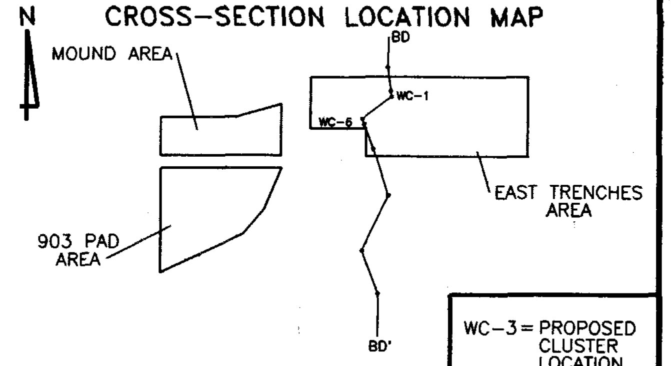


* GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS



NOTE: DISTANCE SHOWN BETWEEN WELLS OB20991, 3687BR AND 03091, B217589 ARE NOT TO HORIZONTAL SCALE.

CROSS-SECTION LOCATION MAP



WC-3 = PROPOSED CLUSTER LOCATION

EXPLANATION

- Qal = STREAM ALLUVIUM
- Qc = COLLUVIUM
- Qrf = ROCKY FLATS ALLUVIUM
- No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
- ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
- T/BR = TOP OF BEDROCK
- ● = LOCATION SYMBOL
- 3486 = LOCATION NAME
- 5912.00 = GROUND SURFACE ELEVATION (ft)

(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

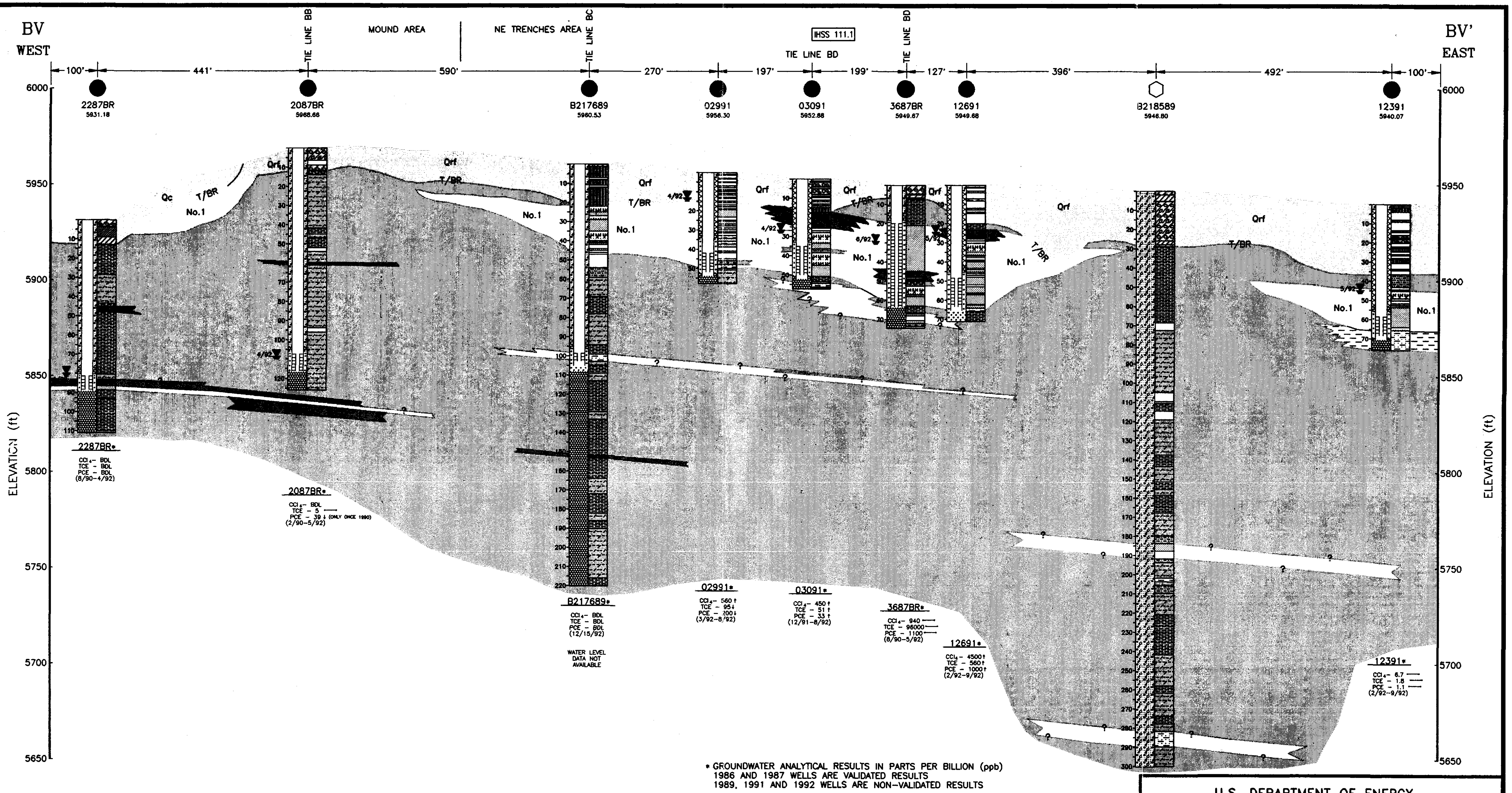
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

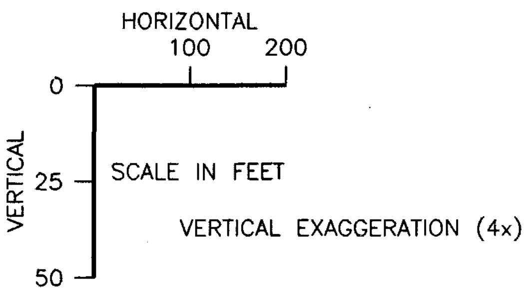
OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

GEOLOGIC CROSS-SECTION BD-BD'

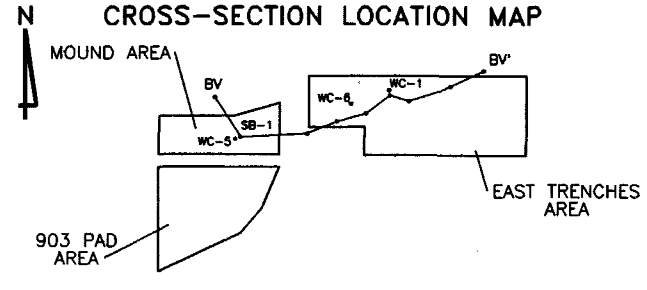
FIGURE 1-18 MARCH 1993

RFL0063





CROSS-SECTION LOCATION MAP



SB-1 = PROPOSED SOURCE BOREHOLE LOCATION
WC-3 = PROPOSED CLUSTER LOCATION

EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

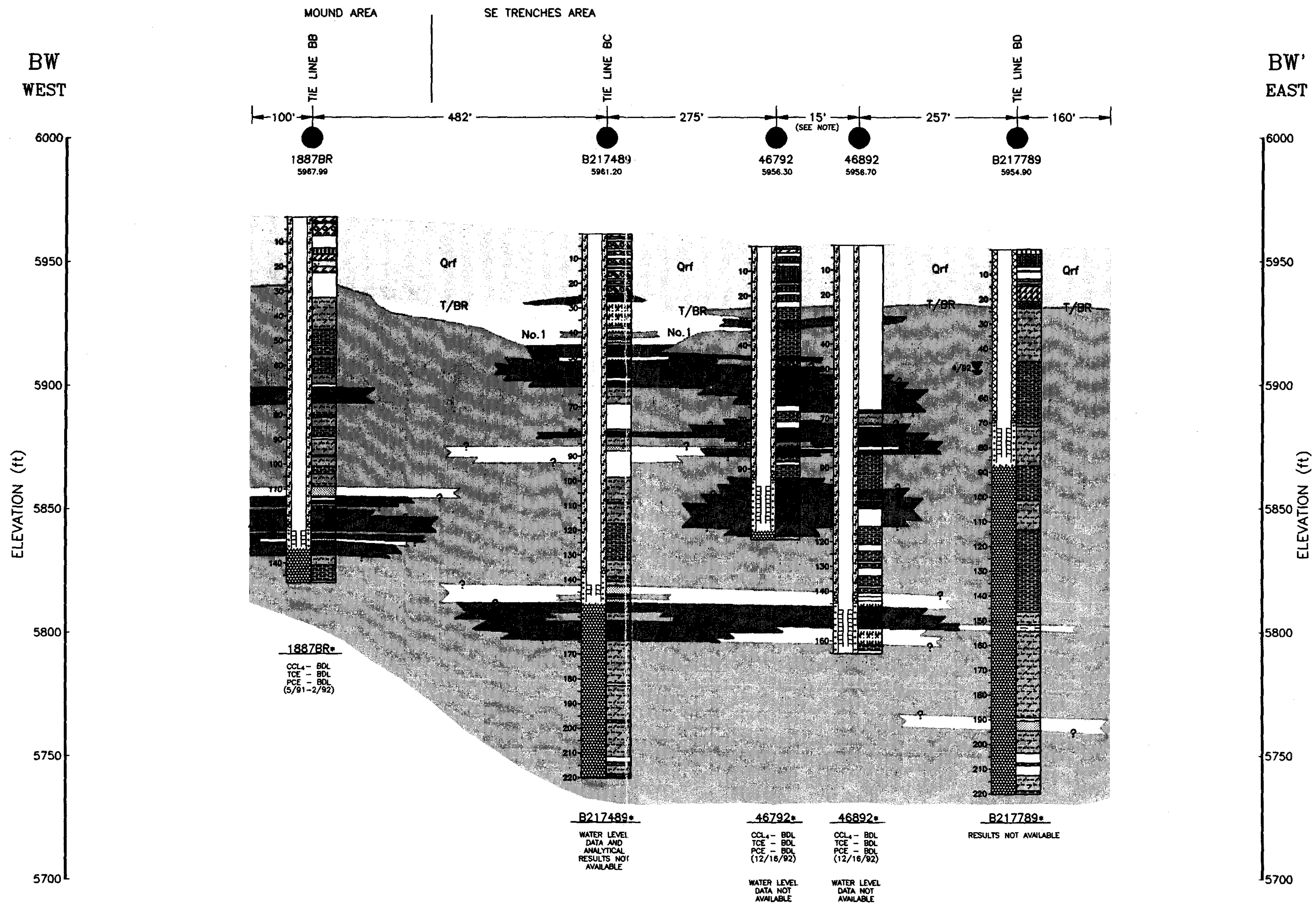
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

GEOLOGIC CROSS-SECTION BV-BV'

FIGURE 1-19 MARCH 1993

RFL0064



• GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS

HORIZONTAL
0 100 200

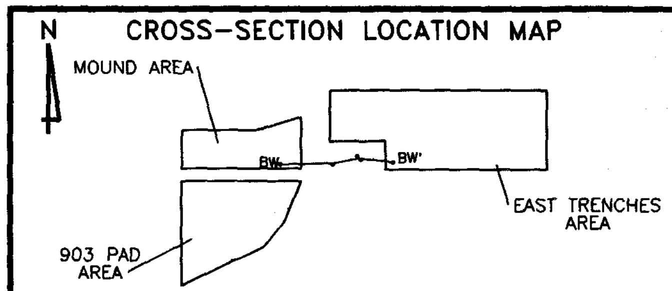
VERTICAL
0 25 50

SCALE IN FEET

VERTICAL EXAGGERATION (4x)

NOTE: DISTANCE SHOWN BETWEEN WELLS 46792, 46892 IS NOT TO HORIZONTAL SCALE.

CROSS-SECTION LOCATION MAP



EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

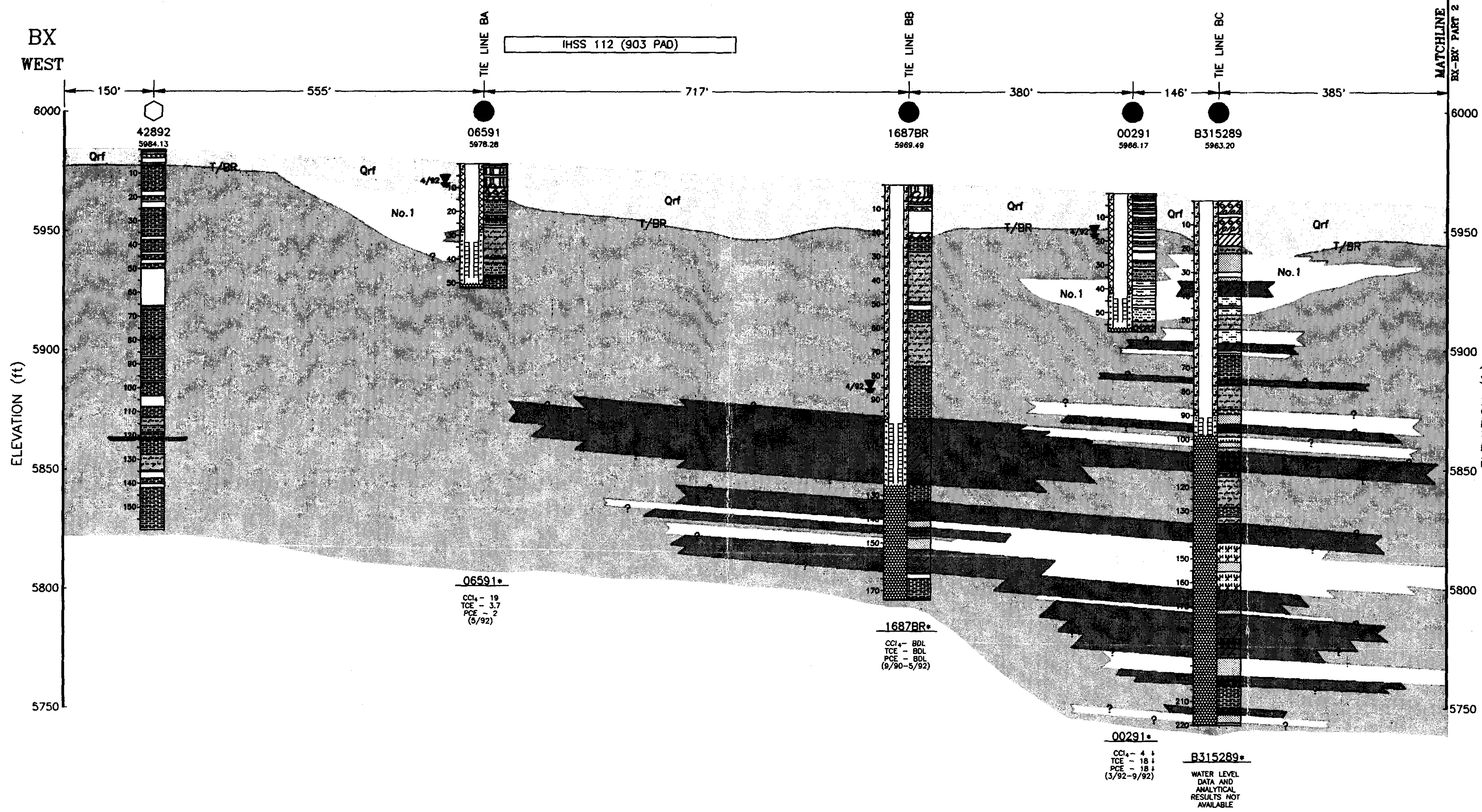
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

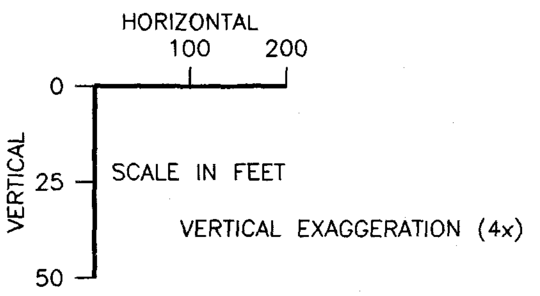
GEOLOGIC CROSS-SECTION BW-BW'

FIGURE 1-20 MARCH 1993

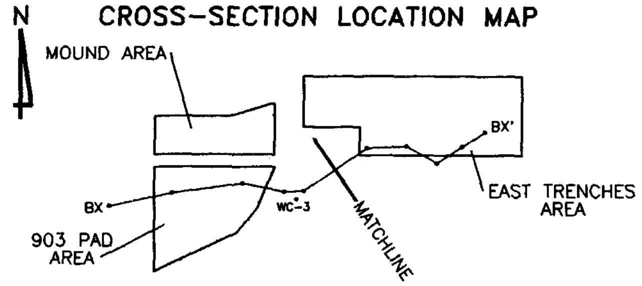
RFL0065



• GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS



CROSS-SECTION LOCATION MAP



WC-3 = PROPOSED CLUSTER LOCATION

EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

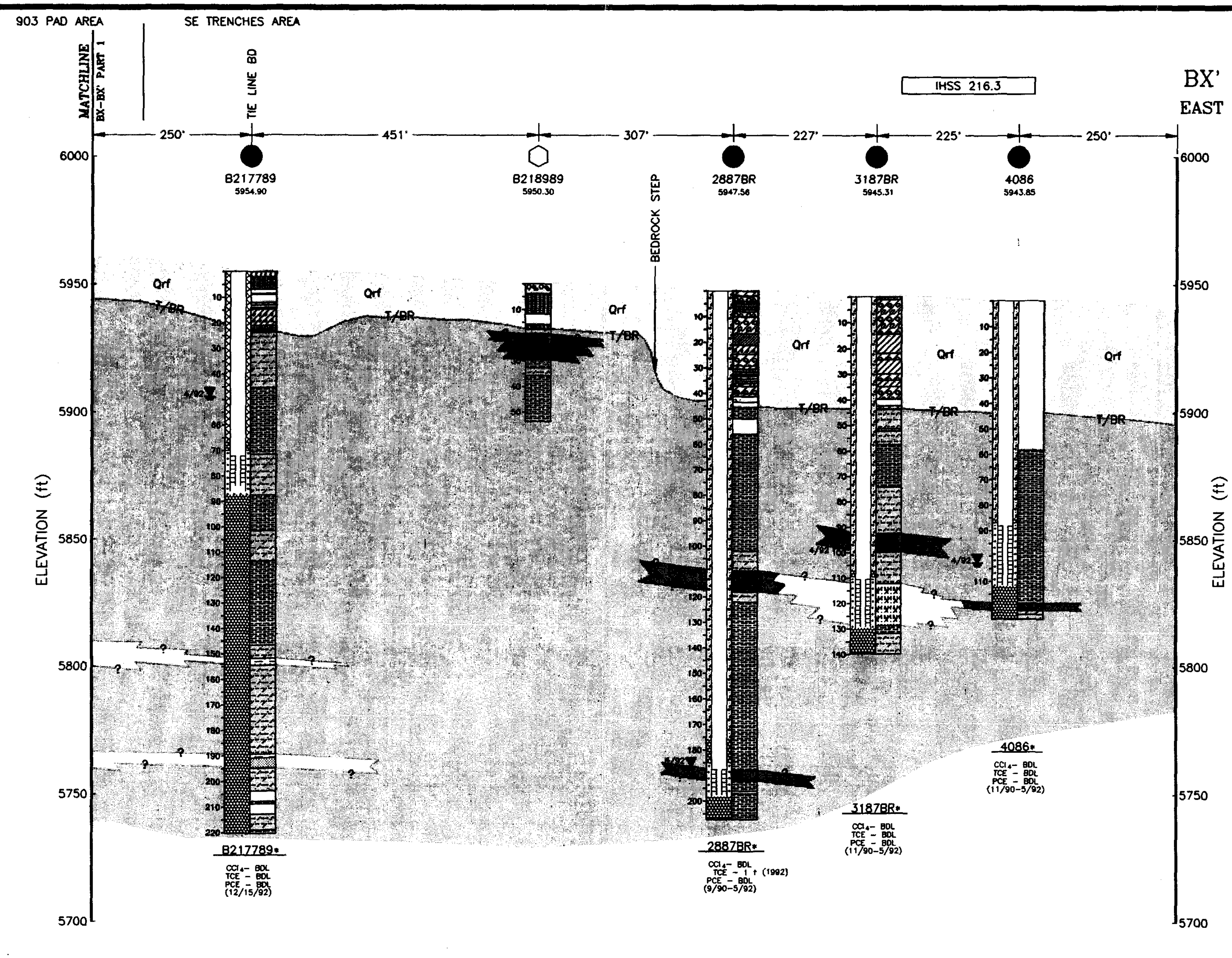
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

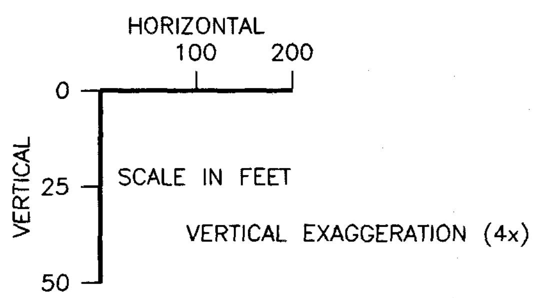
GEOLOGIC CROSS-SECTION BX-BX'
PART 1 OF 2

FIGURE 1-21(a) MARCH 1993

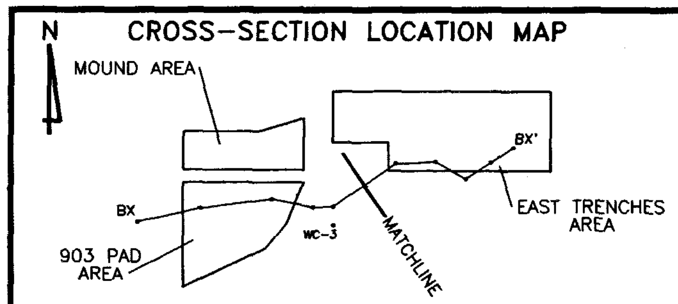
RFL0066



* GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS



CROSS-SECTION LOCATION MAP



WC-3 = PROPOSED CLUSTER LOCATION

EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

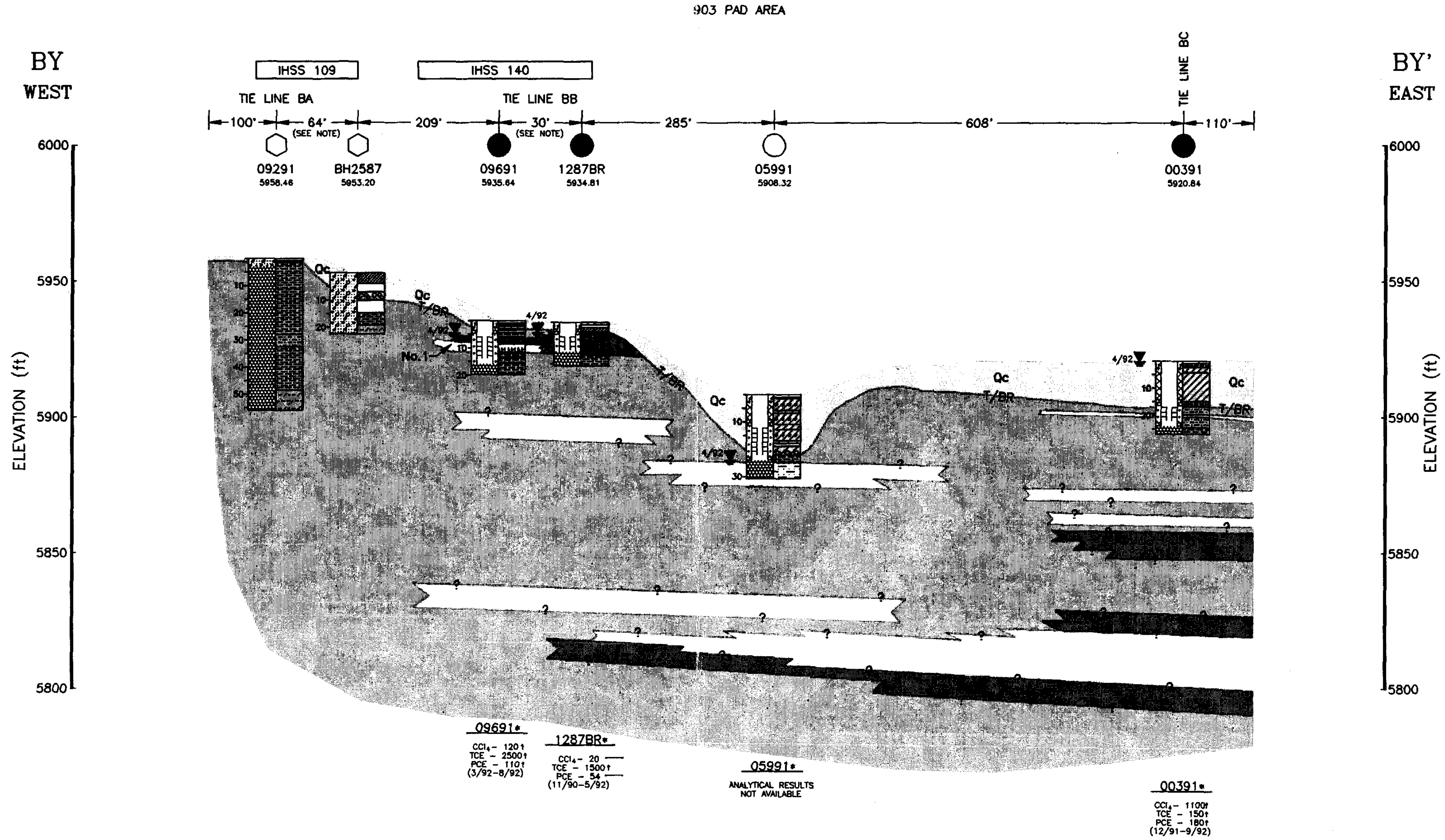
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

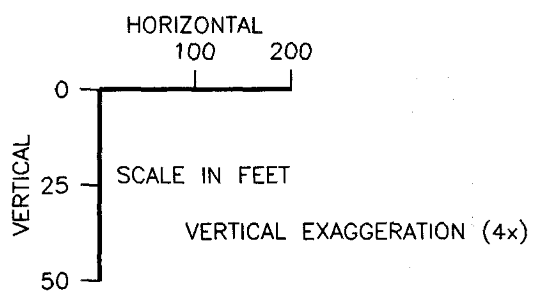
GEOLOGIC CROSS-SECTION BX-BX' PART 2 OF 2

FIGURE 1-21(b) MARCH 1993

RFL0067

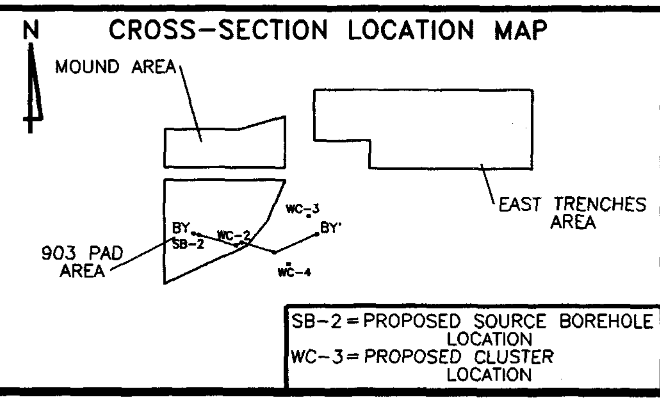


* GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS



NOTE: DISTANCE SHOWN BETWEEN WELLS 09291, BH2587 AND 09691, 1287BR ARE NOT TO HORIZONTAL SCALE.

CROSS-SECTION LOCATION MAP



SB-2 = PROPOSED SOURCE BOREHOLE LOCATION
WC-3 = PROPOSED CLUSTER LOCATION

EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

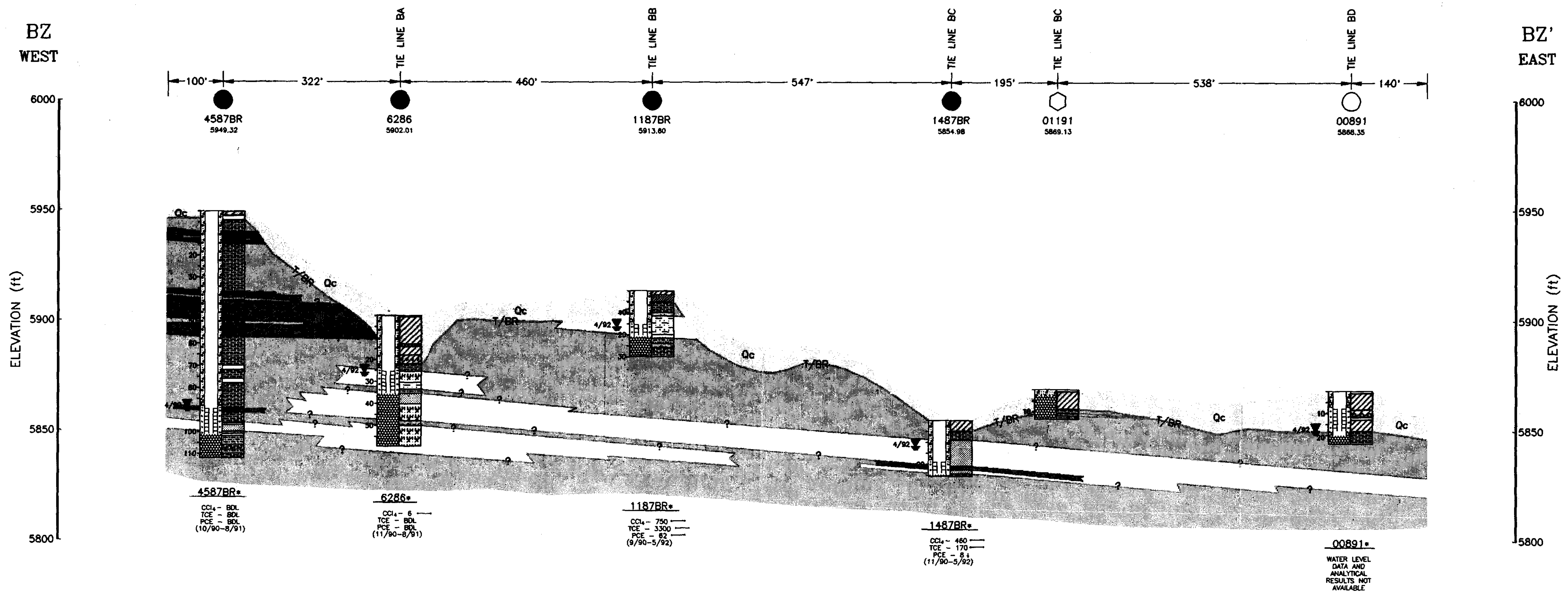
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

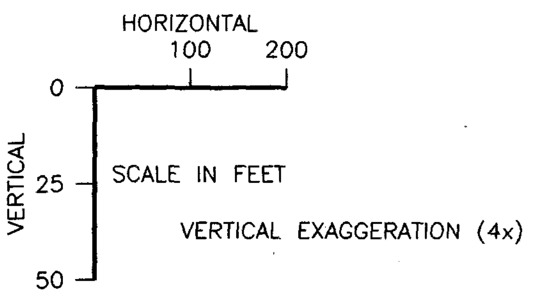
GEOLOGIC CROSS-SECTION BY-BY'

FIGURE 1-22 MARCH 1993

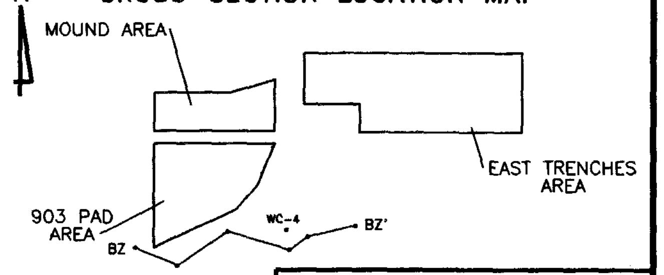
RFL0068



* GROUNDWATER ANALYTICAL RESULTS IN PARTS PER BILLION (ppb)
1986 AND 1987 WELLS ARE VALIDATED RESULTS
1989, 1991 AND 1992 WELLS ARE NON-VALIDATED RESULTS



CROSS-SECTION LOCATION MAP



WC-4 = PROPOSED CLUSTER LOCATION

EXPLANATION

Qal = STREAM ALLUVIUM
Qc = COLLUVIUM
Qrf = ROCKY FLATS ALLUVIUM
No.1 = ARAPAHOE FORMATION (FM) SANDSTONE
ALL SANDSTONES BELOW THE BASE OF THE No.1 SANDSTONE (ARAPAHOE FM) ARE LARAMIE FM SANDSTONES
T/BR = TOP OF BEDROCK
● = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)
(SEE LEGEND PAGE FOR MORE ON SYMBOLS AND ANALYTE DATA)

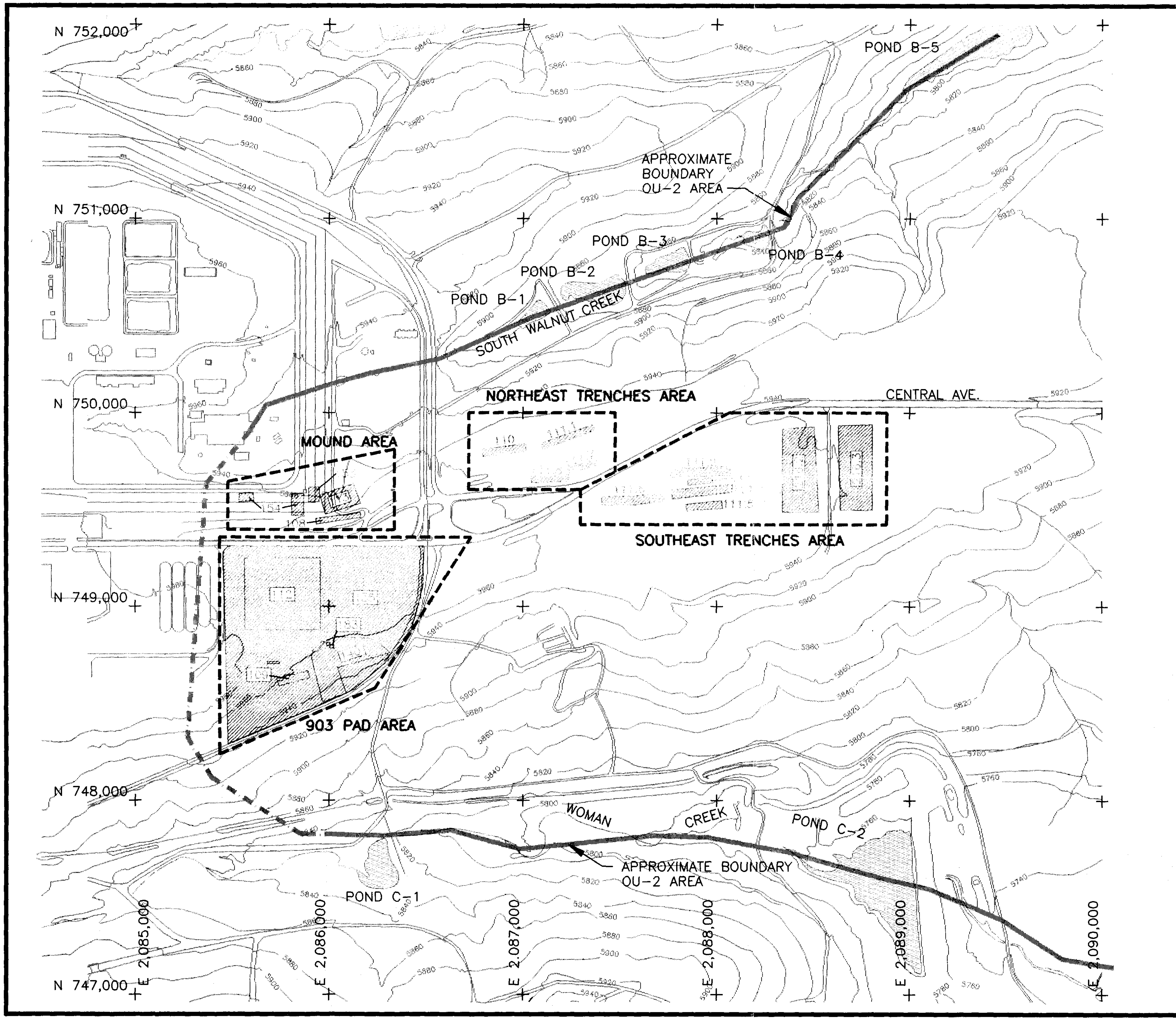
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

GEOLOGICAL CROSS-SECTION BZ-BZ'

FIGURE 1-23 MARCH 1993

RFL0069



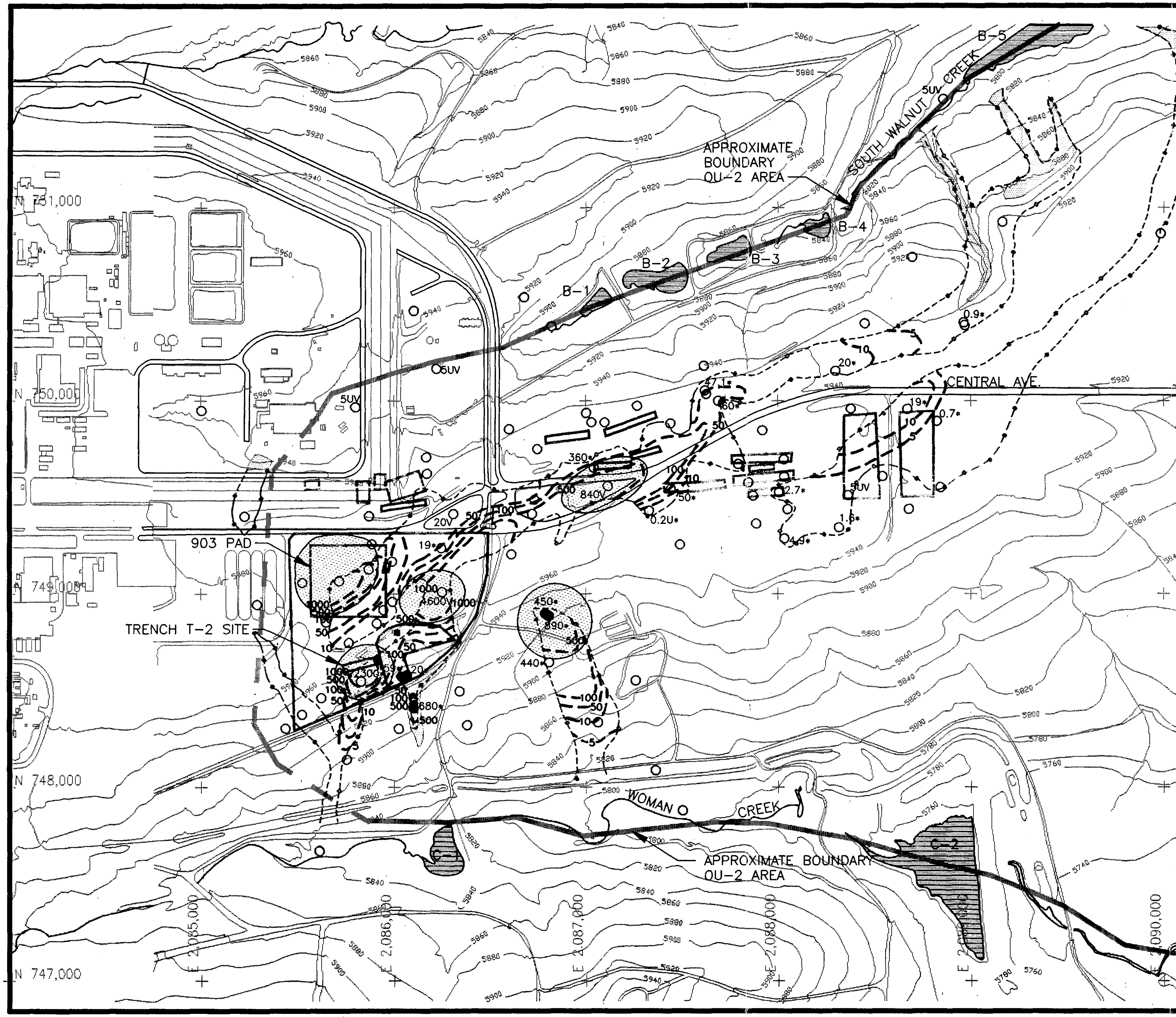
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

INDIVIDUAL HAZARDOUS SUBSTANCE SITES

FIGURE 1-24 MARCH 1993

RFL-0074



EXPLANATION

- 1991–1992 BEDROCK MONITORING WELL
- PRE–1990 BEDROCK MONITORING WELL
- 1991–1992 ALLUVIAL MONITORING WELL
- PRE–1990 ALLUVIAL MONITORING WELL
- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
- APPROXIMATE BOUNDARY OF OU–2 AREA
- VEGETATED AREAS ASSOCIATED WITH ALLUVIAL CONTACT GROUND WATER SEEPS
- APPROXIMATE LOCATION OF IDENTIFIED UHSU CCl_4 HOTSPOT. LIMITS OF STIPPLED PATTERN ARE NOT INTENDED TO DEFINE AREAL EXTENT OF CCl_4 PLUME.

470V = CCl_4 CONCENTRATOIN ($\mu g/L$). DATA QUALITY DESIGNATOR DEFINED AS:

- V = VALIDATED
- A = ACCEPTED
- J = ESTIMATED
- U = NOT DETECTED
- • = NOT VALIDATED
- = LINE OF EQUAL CCl_4 CONCENTRATION ($\mu g/L$)
- = LATERAL EXTENT OF SATURATED ALLUVIUM/COLLUVIAM

DRAFT

-N-

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

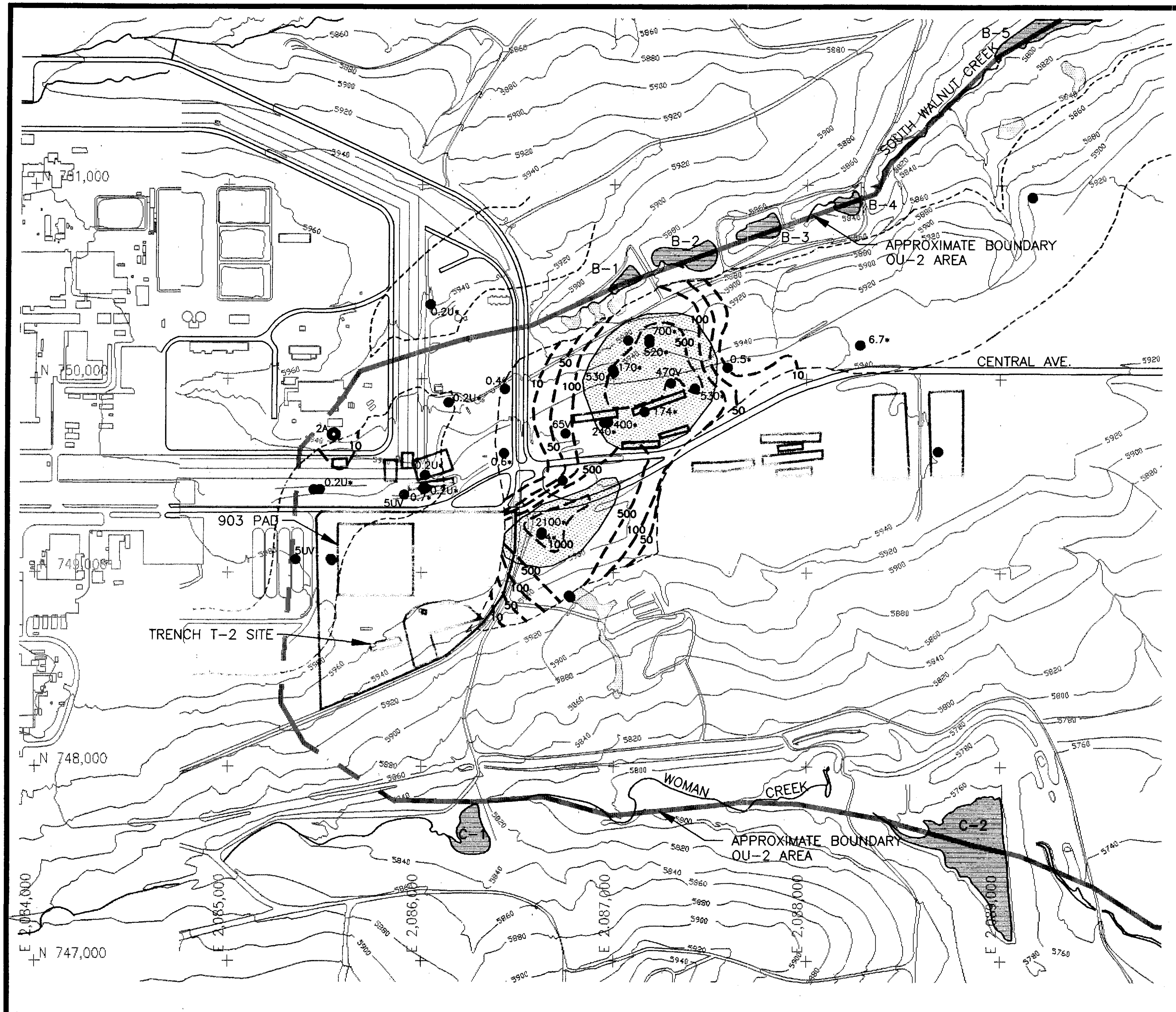
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

CARBON TETRACHLORIDE
ISOCONCENTRATION MAP
FOR THE ALLUVIAL/COLLUVIAL
UHSU GROUNDWATER FLOW SYSTEM
FIRST QUARTER 1992

FIGURE 1–25 **MARCH 1993**

RFL0041



EXPLANATION

- ● 1991-1992 NO. 1 SANDSTONE OR UHSU BEDROCK MONITORING WELL
- ● PRE-1987 NO. 1 SANDSTONE OR UHSU BEDROCK MONITORING WELL
- ◉ SURFACE WATER (SEEP) SAMPLING LOCATION
- □ INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
- APPROXIMATE BOUNDARY OF OU-2 AREA
- VEGETATED AREAS ASSOCIATED WITH NO.1 SANDSTONE GROUND WATER SEEPS
- APPROXIMATE LOCATION OF IDENTIFIED UHSU CCl_4 HOTSPOT. LIMITS OF STIPPLED PATTERN ARE NOT INTENDED TO DEFINE AREAL EXTENT OF CCl_4 PLUME.

470V = CCl_4 CONCENTRATOIN ($\mu g/L$). DATA QUALITY DESIGNATOR DEFINED AS:

- V = VALIDATED
- A = ACCEPTED
- J = ESTIMATED
- U = NOT DETECTED
- * = NOT VALIDATED
- = LINE OF EQUAL CCl_4 CONCENTRATION ($\mu g/L$)
- = LATERAL EXTENT OF NO.1 SANDSTONE

-N-

DRAFT

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

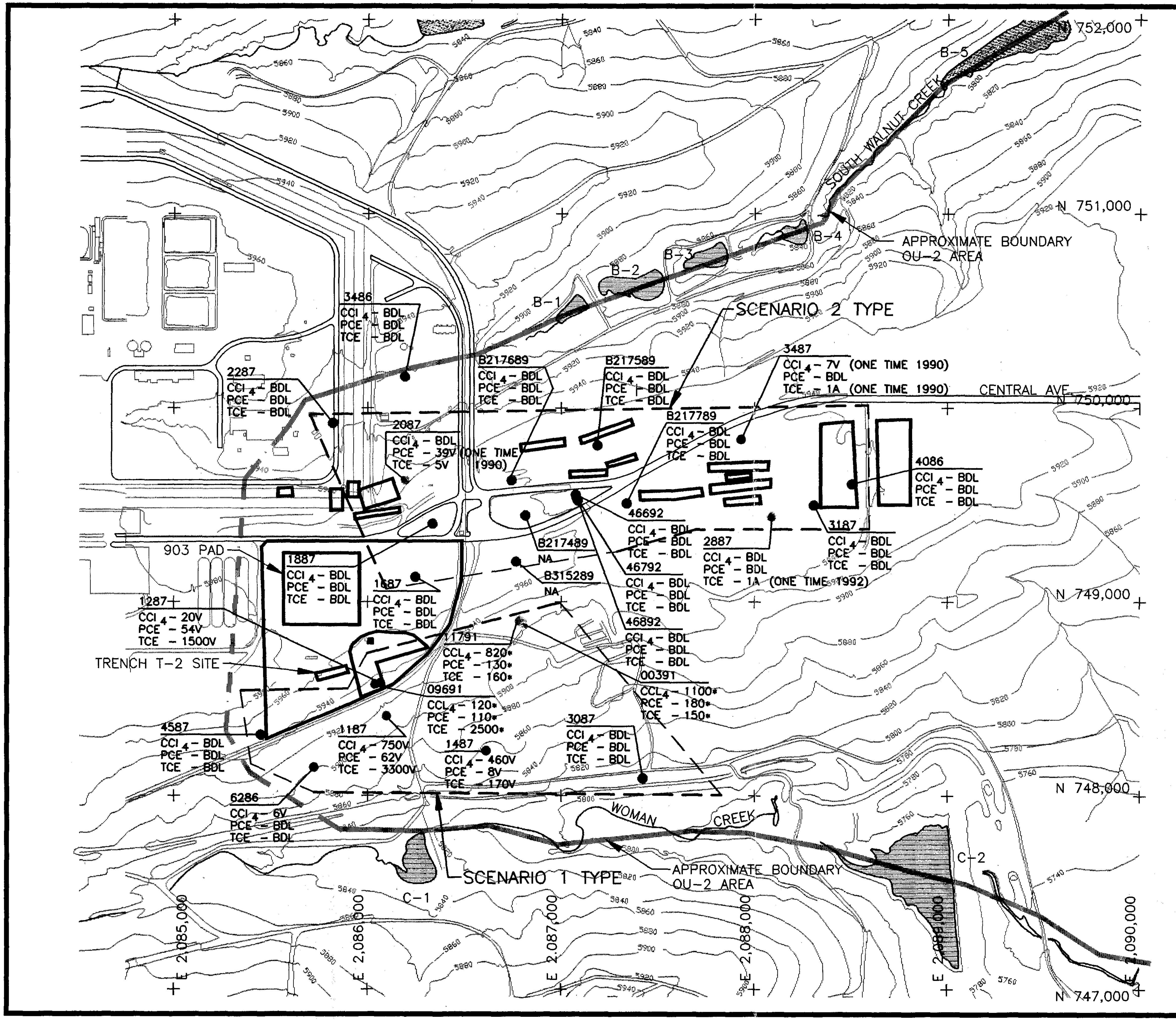
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

CARBON TETRACHLORIDE
ISOCONCENTRATION MAP
FOR THE NO. 1 SANDSTONE
UHSU GROUNDWATER FLOW SYSTEM
FIRST QUARTER 1992

FIGURE 1-26 **MARCH 1993**

RFL0044



EXPLANATION

- ● LHSU MONITORING WELL WITH CHC DETECTION
- ● LHSU MONITORING WELL WITHOUT CHC DETECTION (WELL 06491 IS LOCATED OFF THE MAP TO THE EAST)
- □ INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
- APPROXIMATE BOUNDARY OF OU-2 AREA

3187 — WELL NUMBER
CCl 4 - BDL
PCE - BDL
TCE - BDL — CONCENTRATION (ppb)

DATA QUALITY DESIGNATION DEFINED AS:

*	NON-VALIDATED RESULT
V	VALIDATED RESULT
A	ACCEPTED RESULT
NA	ANALYTICAL RESULT NOT AVAILABLE
BDL	BELOW DETECTION LIMIT
CCl_4	CARBON TETRACHLORIDE
PCE	TETRACHLOROETHENE
TCE	TRICHLOROETHENE
450	ANALYTICAL RESULTS IN ppb

-N-

DRAFT

SCALE : 1 INCH = 500 FEET

500' 0 500'

CONTOUR INTERVAL = 20'

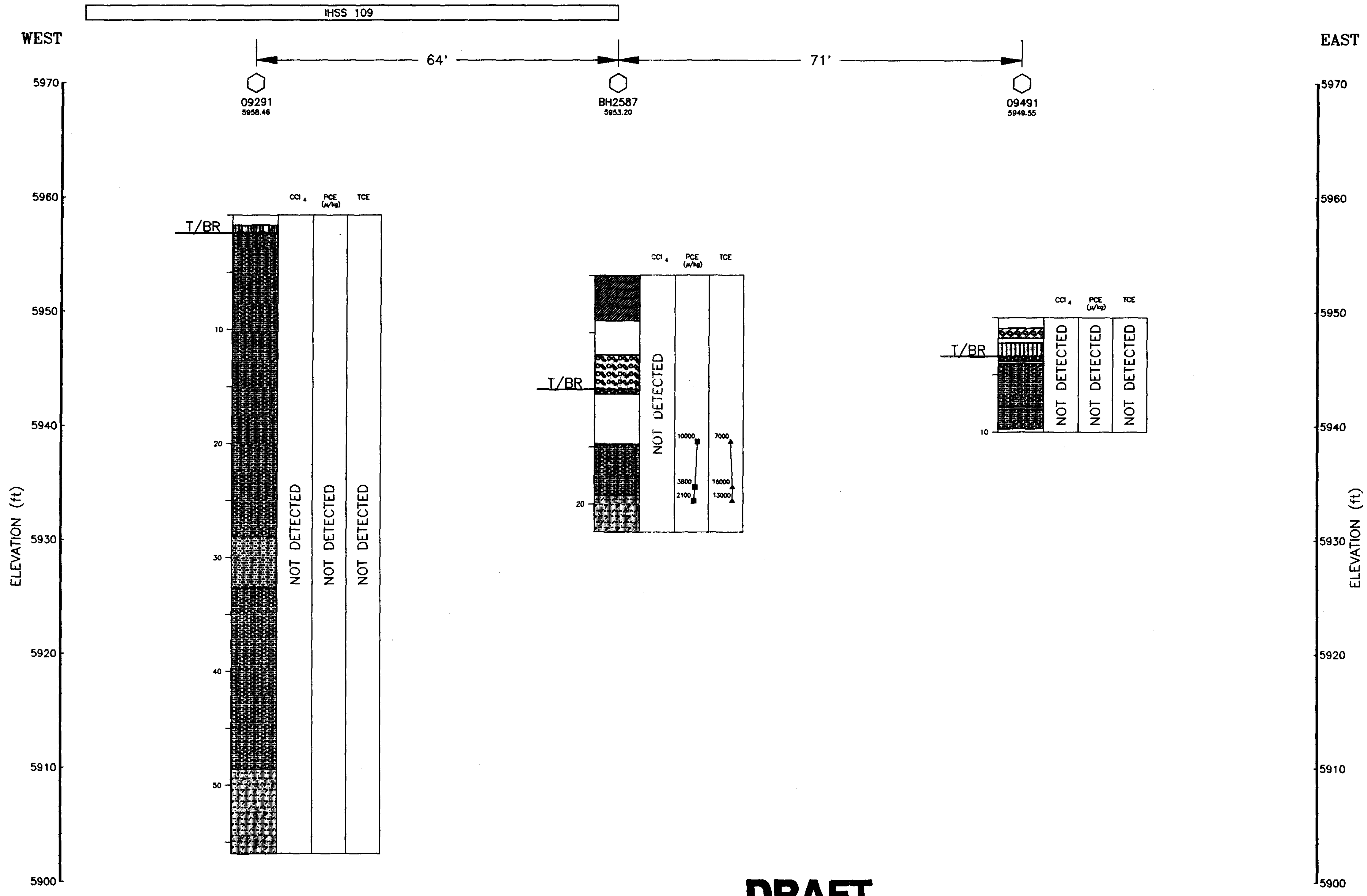
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

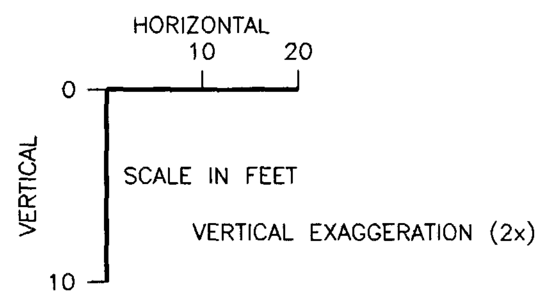
CARBON TETRACHLORIDE, TETRACHLOROETHENE, AND TRICHLOROETHENE DETECTION SINCE 1990 IN LHSU GROUNDWATER

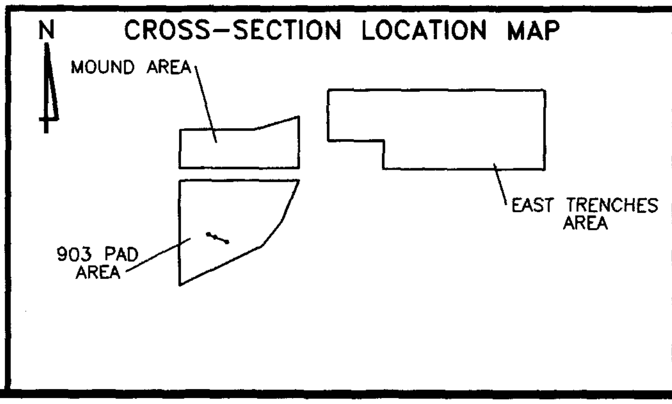
FIGURE 1-29 **MARCH 1993**

RFL0049



DRAFT





EXPLANATION

T/BR = TOP OF BEDROCK
⬡ = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)

● = CARBON TETRACHLORIDE (CCl_4)
■ = TETRACHLOROETHENE (PCE)
▲ = TRICHLOROETHENE (TCE)

EACH CHEMICAL COLUMN IS A LOGARITHMIC SCALE (INCREASING TO RIGHT) FROM 1 TO 1,000,000 (µg/kg)

(SEE FIGURE 1-14, GEOLOGIC CROSS-SECTION LEGEND, FOR SOIL, BEDROCK AND LOCATION SYMBOLS)

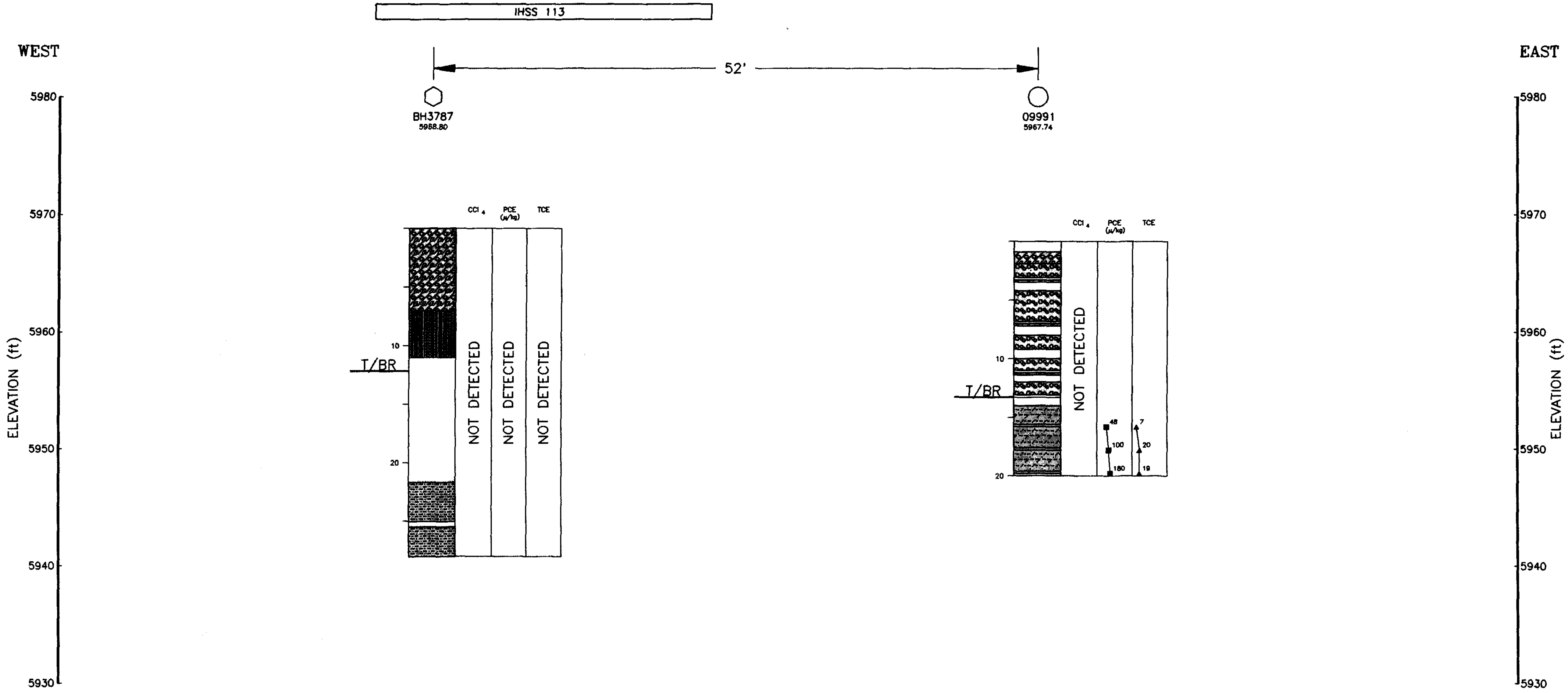
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

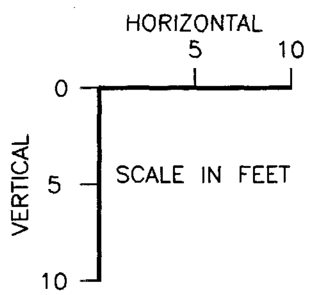
SOURCE BOREHOLE CHARACTERIZATION IHSS 109 (903 PAD AREA)

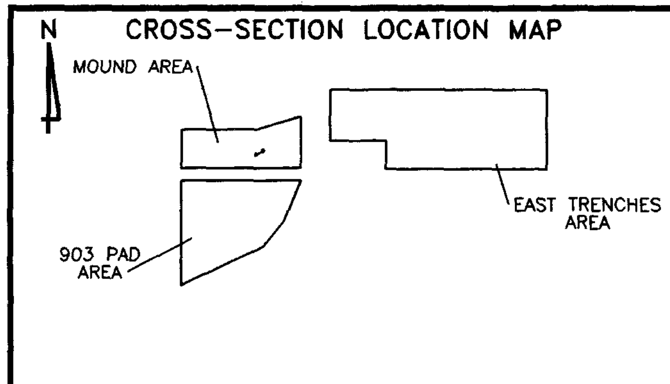
FIGURE 1-30 MARCH 1993

RFL0072



DRAFT





EXPLANATION

T/BR = TOP OF BEDROCK
⬡ = LOCATION SYMBOL
3486 = LOCATION NAME
5912.00 = GROUND SURFACE ELEVATION (ft)

• = CARBON TETRACHLORIDE (CCl_4)
▪ = TETRACHLOROETHENE (PCE)
▴ = TRICHLOROETHENE (TCE)

EACH CHEMICAL COLUMN IS A LOGARITHMIC SCALE (INCREASING TO RIGHT) FROM 1 TO 1,000,000 (µg/kg)

(SEE FIGURE 1-14, GEOLOGIC CROSS-SECTION LEGEND, FOR SOIL, BEDROCK AND LOCATION SYMBOLS)

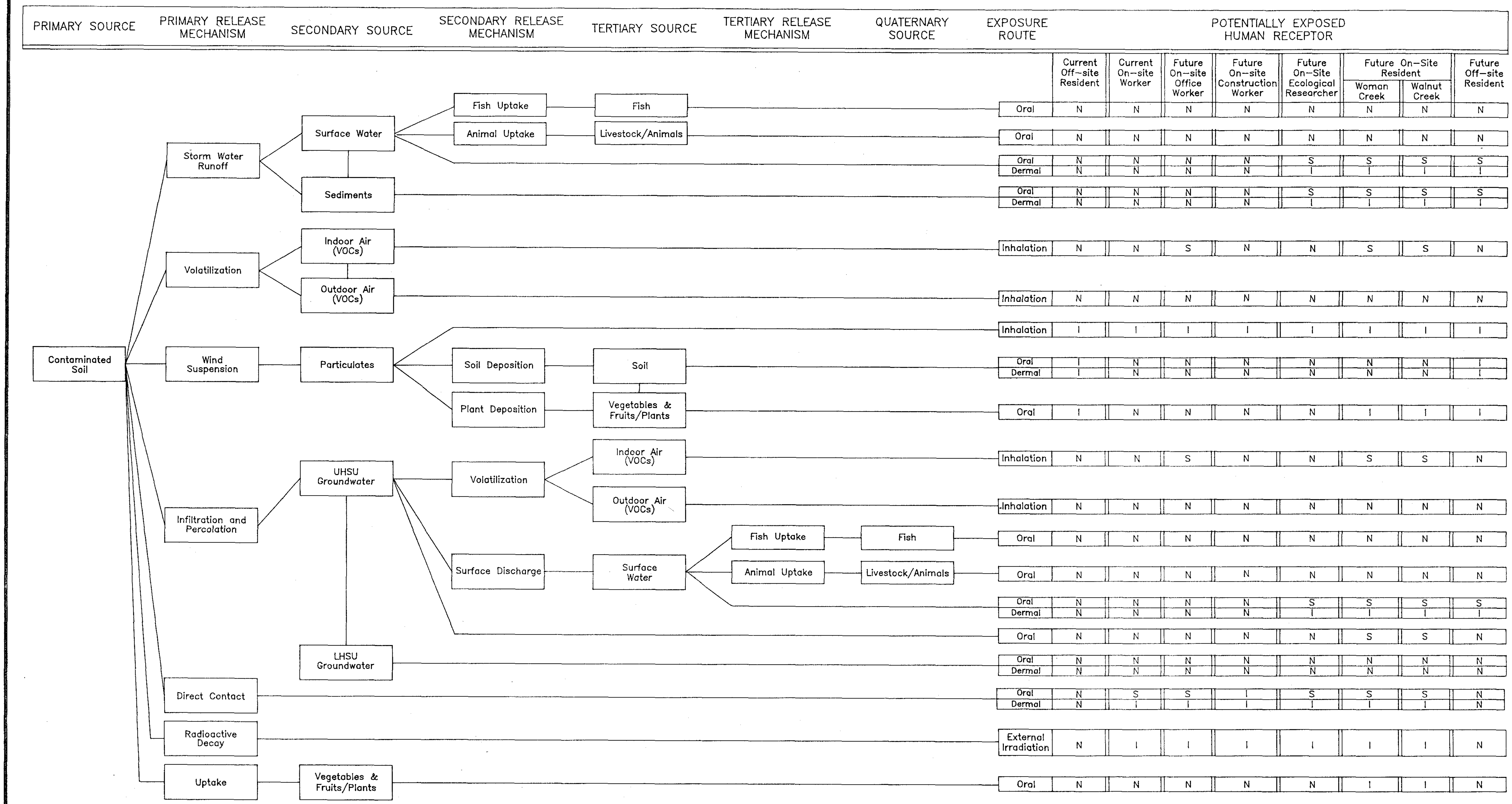
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

SOURCE BOREHOLE CHARACTERIZATION IHSS 113 (MOUND AREA)

FIGURE 1-31 MARCH 1993

RFL0073

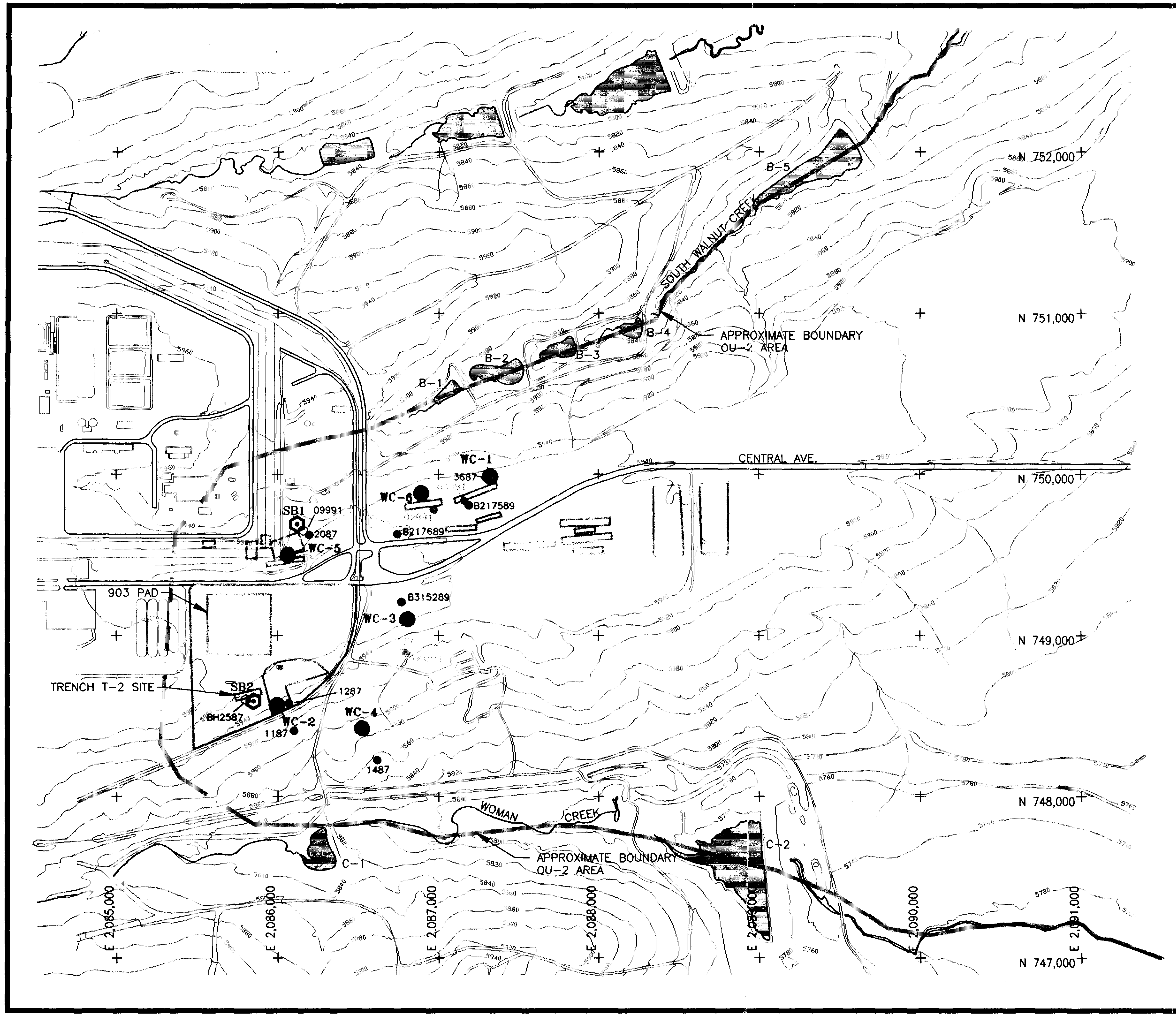


LEGEND
S = Significant Potential Exposure Pathway
I = Insignificant Potential Exposure Pathway
N = Negligible or Incomplete Exposure Pathway
UHSU = Upper Hydrostratigraphic Unit
LHSU = Lower Hydrostratigraphic Unit

Note: Significant and insignificant potential exposure pathways will be quantitatively evaluated.

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8
CONCEPTUAL SITE MODEL
FOR ROCKY FLATS OU-2
FIGURE 1-32   MARCH, 1993

RFCONC1



EXPLANATION

- 1991–1992 BEDROCK MONITORING WELL
- BOREHOLE
- HISTORICAL BEDROCK MONITORING WELL
- INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
- APPROXIMATE BOUNDARY OF OU-2 AREA

PROPOSED LOCATIONS

- WC-1 PROPOSED LHSU BEDROCK WELL CLUSTER
- SB1 SOURCE BOREHOLE

-N-

SCALE : 1 INCH = 600 FEET

600' 0 600'

CONTOUR INTERVAL = 20'

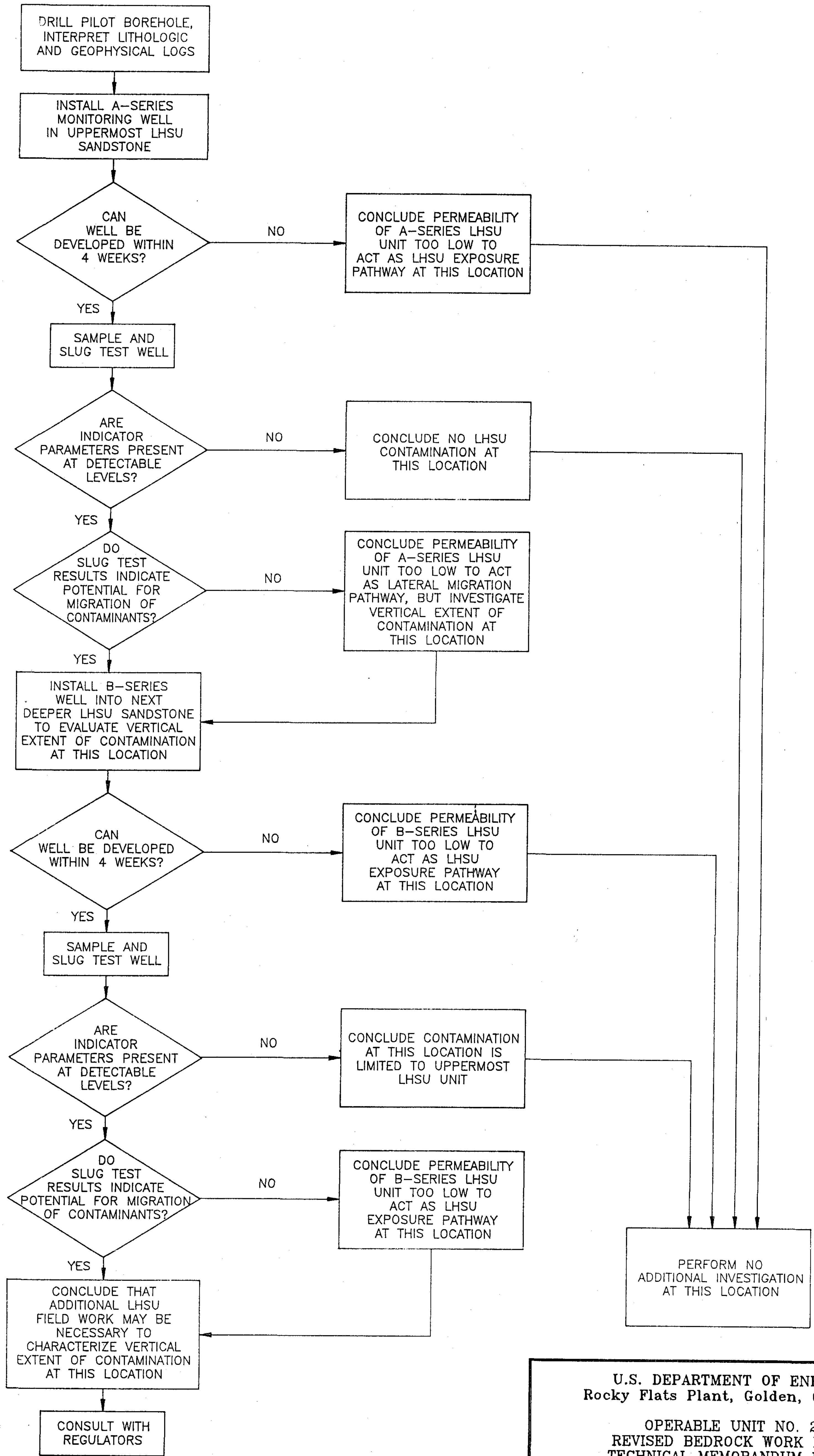
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

PROPOSED INVESTIGATION LOCATIONS

FIGURE 2-1 **MARCH 1993**

RFL0054



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

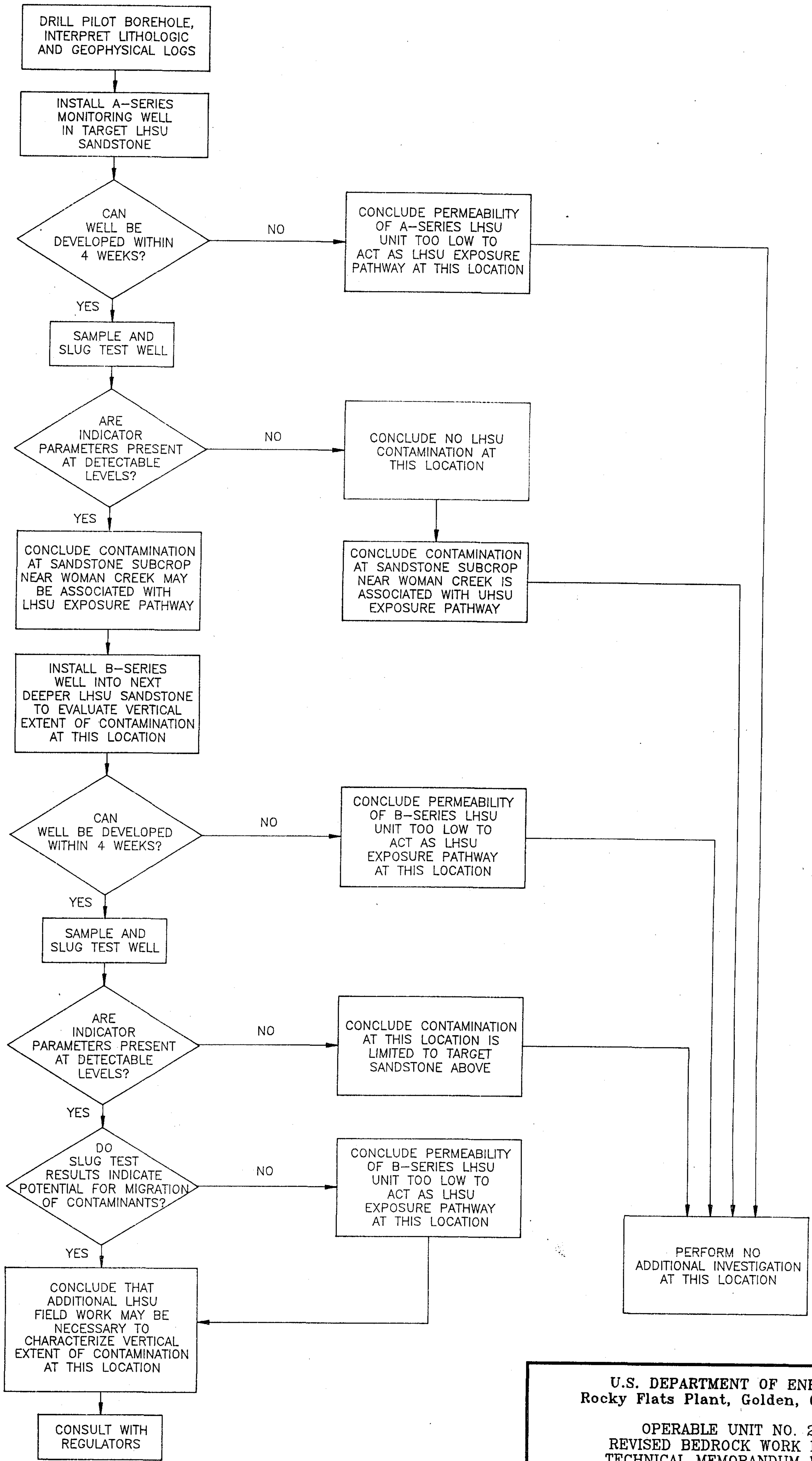
OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DECISION PATH DIAGRAM FOR FIELD WORK AT LOCATIONS WC-1, WC-5, AND WC-6

FIGURE 2-4

MARCH 1993

3407E18



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

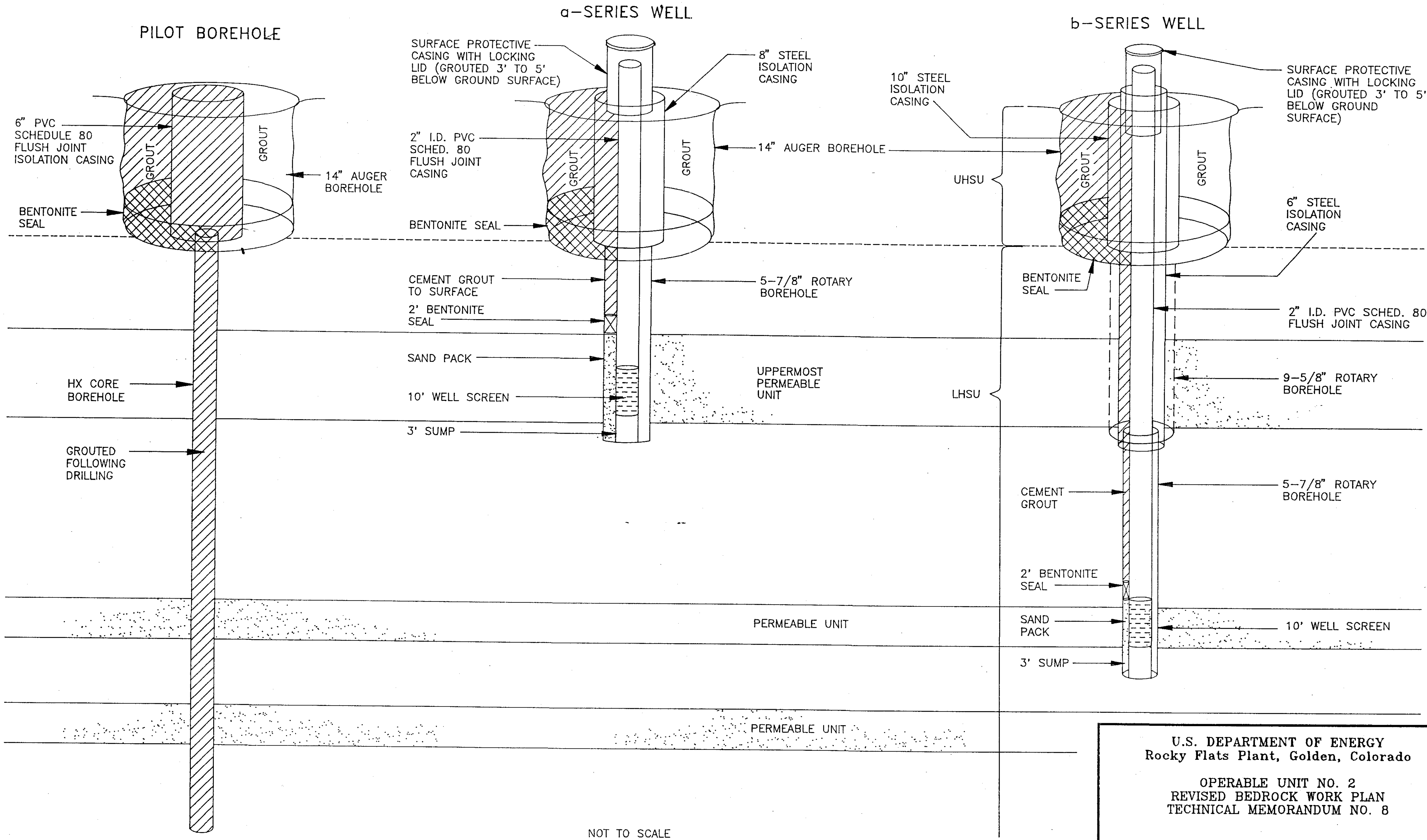
OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DECISION PATH DIAGRAM
FOR FIELD WORK AT LOCATIONS
WC-2, WC-3, AND WC-4

FIGURE 2-6

MARCH 1993

3407E19



U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

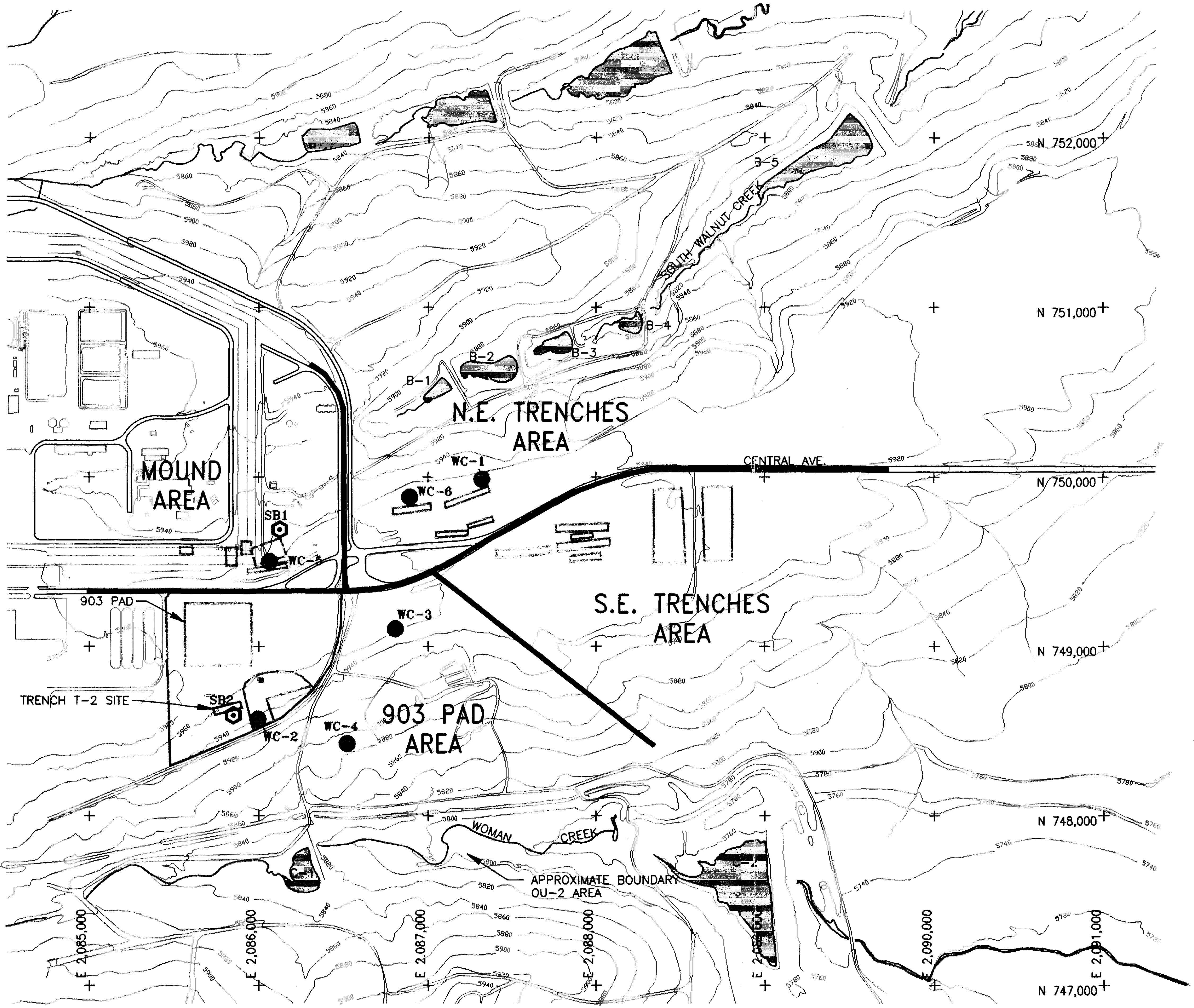
OPERABLE UNIT NO. 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO. 8

DIAGRAM OF TYPICAL
LHSU WELL CLUSTER

FIGURE 2-9

MARCH 1993

3047E08



EXPLANATION

INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION

DECONTAMINATION BOUNDARY LINES

PROPOSED LOCATIONS

WC-1 PROPOSED LHSU BEDROCK WELL CLUSTER

SB1 SOURCE BOREHOLE

-N-

SCALE : 1 INCH = 600 FEET

600' 0 600'

CONTOUR INTERVAL = 20'

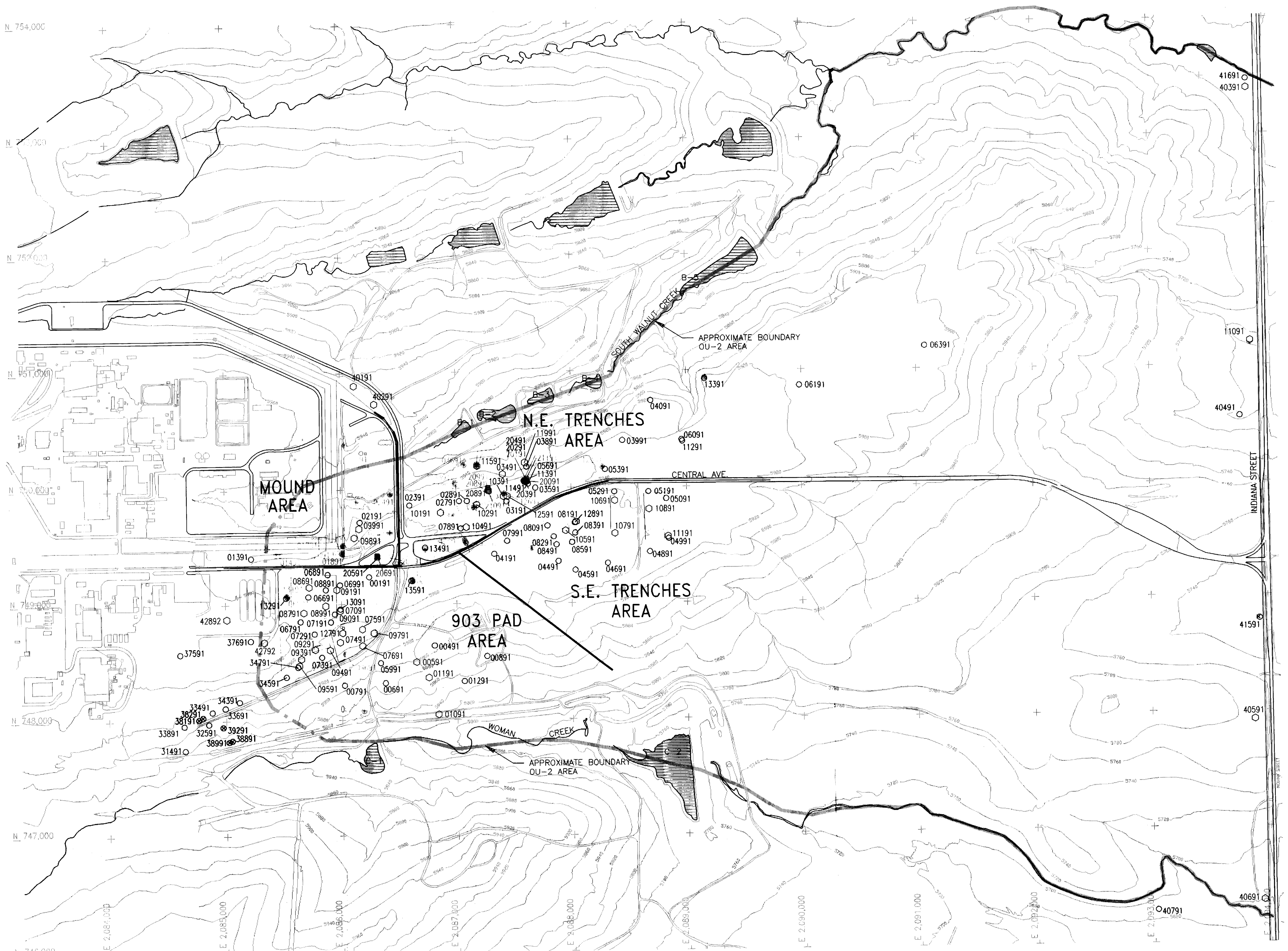
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

DECONTAMINATION BOUNDARIES

FIGURE 2-10 MARCH 1993

RFL0053



EXPLANATION

		1991-1992 BEDROCK MONITORING WELL
00691	○	1991 ALLUVIAL MONITORING WELL
11191	○	1991 AND 1992 BOREHOLE
38291	⊗	PIEZOMETER
20291	□	ALLUVIAL OBSERVATION WELL
20091	▲	BEDROCK PUMPING WELL
		BEDROCK OBSERVATION WELL
		INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
		APPROXIMATE BOUNDARY OF OU-2 AREA

-N-

SCALE : 1 INCH = 500 FEET

1000' 0 1000'

CONTOUR INTERVAL = 20'

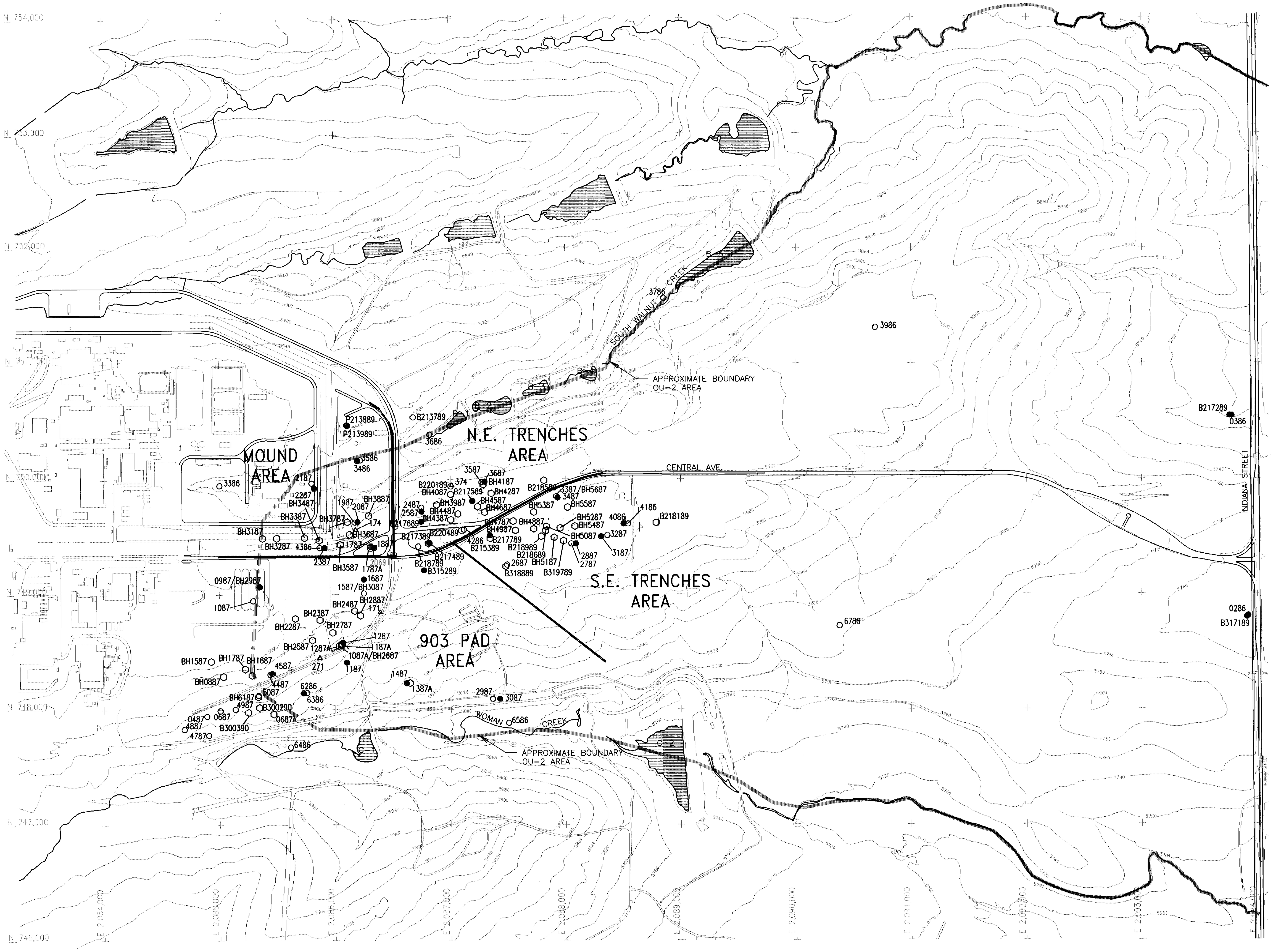
U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

1991 AND 1992 MONITORING WELL AND BOREHOLE LOCATIONS

PLATE 1-2 MARCH 1993

RFL0052a



EXPLANATION

3486	●	PRE-1990 BEDROCK MONITORING WELL
3586	○	PRE-1990 ALLUVIAL MONITORING WELL
171	△	PRE-1986 MONITORING WELL
38291	○	HISTORICAL BOREHOLE
		INDIVIDUAL HAZARDOUS SUBSTANCE SITE LOCATION
		APPROXIMATE BOUNDARY OF OU-2 AREA

-N-

SCALE : 1 INCH = 500 FEET

1000' 0 1000'

CONTOUR INTERVAL = 20'

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 2
REVISED BEDROCK WORK PLAN
TECHNICAL MEMORANDUM NO.8

PRE-1990 MONITORING WELL AND BOREHOLE LOCATIONS

PLATE 1-1 MARCH 1993

RFL0051a